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EMPIRICAL ESSAYS ON OPEN INNOVATION

BY

GREGORY JOHN FISHER

DISSERTATION

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Doctoral Committee:

Professor William J. Qualls, Chair  
Professor Aric Rindfleisch  
Professor Rajagopal Echambadi  
Associate Professor Eric (Er) Fang

## **Abstract**

This dissertation offers an integrative conceptual framework and research studies that provide theoretical and empirical explanations for important mechanisms that enable new product outcomes from different approaches to open innovation. The literature review classifies various forms of open innovation along the two key dimensions of the organizer of open innovation activities and the intended consumer of the open innovation output. This unique perspective of open innovation enables this dissertation to investigate open innovation from the supply-side, in terms of the firms and individuals who collaborate to create new products. Additionally, this unique approach enables this dissertation to explore the demand-side perspective, in terms of the consumers who use the new products that are created via open innovation.

One chapter of this dissertation explores a specific, supply-side form of open innovation that is termed “open contribution.” With open contribution, a firm allows external organizations and individuals to actively participate in its development of new products. While the firm permits external contributions to its new product development (NPD) process, it retains internal control over the resulting innovation output. This chapter advances the emerging adaptive marketing capabilities theoretical perspective that includes vigilant market learning, adaptive market experimentation, and open marketing as important mechanisms that firms leverage to create and commercialize innovations. This study bridges adaptive marketing capabilities to the open innovation literature to delineate how open contribution, through external knowledge search and diverse external stakeholder involvement, influences NPD outcomes.

This research builds a dynamic marketing capabilities conceptual framework that hypothesizes the effects of open contribution on adaptive marketing capabilities and innovation performance. The study empirically tests the hypotheses with partial least squares using primary survey data from 203 respondents. The results reveal that the ability to predict new product outcomes is substantially improved with the addition of adaptive marketing capabilities. Firms that focus on open contribution may search their environment effectively but fail to utilize the external knowledge to create innovations. Adaptive marketing capabilities are required internal dynamic firm mechanisms for interpreting and converting the external knowledge into innovations. The findings suggest how firms can develop specific capabilities that are needed to implement open innovation and leverage external knowledge during NPD.

Another chapter of this dissertation considers the demand-side perspective to explore a completely different form of open innovation in which individuals independently innovate and build on other individuals' creative ideas. This approach to open innovation is termed "nonmarket innovation" because it creates new products without any governance or oversight from a professional organization, and because it avoids firm-led marketplace exchanges as a means of diffusing new products. This chapter focuses on the "maker movement," which is a rapidly emerging area of nonmarket innovation in which individuals create original product designs, and communities of users select designs and make products, instead of buying products from firms.

This research expands social production theory to explicate the concept of community selection as a key mechanism that enables individuals to choose new product designs that are created via nonmarket innovation. Social production relies, in part, on the ability of products to be modified by subsequent innovators. This dissertation reveals that the social production

concept of design modification also influences individuals' decisions to select new products that are created through nonmarket innovation.

Further, the community selection process evaluates the reputation of individual designers that share their original product designs. The designer's reputation is an indicator of standing within the community that spills over onto the expected quality of the product designs. This research relies upon a rigorous multi-method approach that includes secondary data and behavioral lab data to test hypotheses in the budding nonmarket innovation context of three-dimensional (3D) printing communities. In particular, the results suggest that the social production concept of design modification influences individuals' decisions to use new products that are created through nonmarket innovation.

By investigating both the supply-side and demand-side aspects of open innovation, this dissertation seeks to accomplish numerous objectives. Theoretically, this dissertation extends several emerging conceptual perspectives to the open innovation literature. The research theoretically delineates open contribution as a specific form of firm-led open innovation and introduces the marketing capabilities literature into the open innovation domain. Additionally, this research conceptually builds upon the emerging view of adaptive marketing capabilities to show how these capabilities enable firms to accomplish specific objectives from open contribution.

Moreover, this dissertation contributes to the development of theory in the open innovation domain by introducing social production theory to the marketing domain. This research extends the social production perspective to incorporate the nonmarket innovation mechanism of community selection. Further, the research suggests the relevance of social

production theory for understanding how users select product designs that are created through nonmarket innovation.

Empirically, this dissertation seeks to make contributions to open innovation through the measurement of several emerging constructs. This research develops original measurement scales to be among the first to operationalize open contribution and the adaptive marketing capabilities of vigilant market learning, adaptive market experimentation, and open marketing. This study empirically tests each of these constructs and links them to specific performance outcomes, which is an ongoing need in the growing literature on open innovation. Further, this research operationalizes several incipient ideas from the social production perspective, including design granularity, design modifiability, and community selection. These constructs are measured via multiple methods and empirically tested to further our knowledge of nonmarket innovation.

Substantively, this dissertation offers numerous insights to practitioners of open innovation. Managers continue to seek guidance on more specific tactics that they should pursue in order to utilize the external knowledge that is increasingly available to their NPD efforts. This dissertation's focus on adaptive marketing capabilities suggests specific capabilities that firms can cultivate and leverage to obtain favorable outcomes from open contribution.

While firms are pursuing open contribution paradigms at an increasing rate, nonmarket innovation communities are new phenomena that are not well-understood and have been greeted with caution and concern by firms. Many incumbent firms view nonmarket innovation as a hazard that possesses the potential to erode the profitable businesses that they have built and protected through years of careful marketing and management effort. While not all firms are threatened by nonmarket innovation, few firms are actively participating in nonmarket

innovation activities. However, such communities of individual innovators are cutting edge developers of emerging innovation processes, and they hold much knowledge that firms can learn from. This dissertation offers exploratory insight into the incipient area of nonmarket innovation and what factors affect individual decisions to use products that are created without the input of firms.

*To Janet,*

*Thomas, Jacob, and Austin*

*Thank you for your love, patience, and support. You make my life complete.*



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## Chapter 1

### Introduction

*“It is now considered axiomatic that success at technological innovation requires the integration of both external knowledge and internal inventiveness”*

*-- (King and Lakhani 2011).*

#### 1. Introduction

Many people imagine the National Aeronautics and Space Administration (NASA) to be a technology incubator that is powered by a stable of brilliant scientists and engineers who collaborate to solve some of humankind’s most complex challenges of flight. This image of NASA as a self-reliant staff of experts is rightfully earned, given NASA’s historic role in developing revolutionary technologies in jet propulsion and supersonic transport (Chambers 2005). Despite its legendary internal expertise, NASA’s current technology strategy includes the use of external expertise that is garnered via open innovation, a paradigm that leverages “purposeful inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively” (Chesbrough 2006).

With unrivaled expertise in flight and space exploration that has been cultivated through decades of research and experience, why has NASA turned to external sources of knowledge in an attempt to solve its current innovation challenges? NASA’s open innovation activities seek to harness the external expertise of citizen scientists because open innovation costs “much less than traditional methods of seeking research and technology solutions,” and because this approach spurs “the rapid development, posting and solution time of weeks for finding potential solutions,

instead of months or years required using more traditional means” (NASA 2010). As a result, organizations that historically have preferred closed innovation processes that rely on internal expertise, such as NASA, are now embracing open innovation because “the answers to the space agency’s toughest problems can come from people who have no experience with space travel at all” (*Knowledge@Wharton* 2013).

Open innovation continues to increase in popularity, as evidenced by its relevance to practice (Bughin 2012; Chesbrough 2012). Large firms, such as Procter & Gamble (P&G), are supplanting their internal research and development (R&D) functions with external intermediaries such as InnoCentive to crowdsource solutions to design problems in order to innovate faster and at a lower cost than competitors (Bayus 2013; Reeves and Deimler 2011). Small upstarts, such as Genzyme, are credited with utilizing external knowledge to successfully challenge the dominant market positions of large industry incumbents (Whelan, Parise, de Valk, and Aalbers 2011). It is well-known that high technology industries have embraced various forms of open innovation for many years (Alexy and Reitzig 2012). But even more conservative industries, such as banking and insurance, have been able to leverage customer involvement in their new product development (NPD) processes to yield an improved new product experience for customers at a lower cost for firms (Ramaswamy and Gouillart 2010a).

Despite the widespread acceptance and growth of open innovation in practice, there is a limited amount of research that investigates the underlying mechanisms that lead to performance outcomes from open innovation. These limitations are expected for an area that is fragmented and is rapidly evolving in practice. Moreover, the research in this area is hindered by the ambiguity about what is included and excluded from the domain of open innovation, and how the various approaches to open innovation are distinct from each other. Chapter 2 of this dissertation

attempts to clarify this issue by reviewing existing literature on open innovation to explain the most prominent types of open innovation, how they are related to each other, how they are different from each other, and how they can be integrated into a common framework. The framework reveals opportunity areas for this dissertation to further explore how firms and individuals utilize open innovation paradigms to achieve new product success.

At the firm level, there is a lack of empirical insight about which capabilities managers should identify and develop to leverage external knowledge and gain a competitive advantage. There is limited systematic evidence that explains and predicts the effects of underlying organizational mechanisms that lead to the favorable outcomes of open innovation (Enkel, Gassmann, and Chesbrough 2009). It remains unclear how firms implement open innovation to benefit the most from leveraging the external knowledge that is also available to numerous competitors within the same industry. The external stimuli of a particular context are infinitely complex, so firms “selectively limit their attention to a limited set of stimuli, while ignoring others” (Ocasio 1997). Researchers should identify the skills that firms need to develop in order to discern which external knowledge is most valuable and relevant for the firm, and how to integrate it with internal knowledge during the firm’s NPD process to improve innovation outcomes. Chapter 3 seeks to answer these questions by analyzing the role of adaptive marketing capabilities when implementing organization-led open innovation.

In particular, chapter 3 investigates vigilant market learning capability, adaptive market experimentation capability, and open marketing capability as important mechanisms that firms leverage to achieve desirable new product outcomes. This study bridges adaptive marketing capabilities to the open innovation paradigm to delineate how open contribution, through external knowledge search and diverse external stakeholder involvement, influences new product

development (NPD) outcomes. With open contribution alone, firms may search their environment for knowledge but not utilize the knowledge to create innovations. Adaptive marketing capabilities are required internal firm mechanisms for interpreting and converting the external knowledge into innovations.

This study empirically tests the hypotheses with Partial Least Squares using primary survey data from 203 respondents and finds that the ability to predict innovation outcomes is substantially improved with the addition of adaptive marketing capabilities, offering several contributions. First, this study builds upon the importance of adaptive marketing capabilities mechanisms and empirically tests their performance consequences in NPD. Second, it improves our understanding of open contribution by revealing adaptive market experimentation capability and open marketing capability as mediating mechanisms that enable the positive new product outcomes from open contribution. Third, this research examines open contribution from an empirical perspective, which advances our knowledge of how open innovation affects performance outcomes. Finally, the insights suggest how firms can purposefully develop specific capabilities that are needed to implement open contribution and leverage external knowledge during NPD.

Chapter 4 departs from the organizational perspective of open innovation to explore how open innovation is rapidly gaining relevance with individuals who create innovations. At the individual consumer level, nonmarket forms of open innovation are emerging in which users are able to innovate without interacting with manufacturers, service providers, or retailers (Rindfleisch 2014). This chapter focuses on incipient open innovation phenomena where individuals, and communities of individuals, independently innovate as part of the maker movement, without any formal oversight from firms. The maker movement is a rapidly emerging

area of nonmarket innovation in which individuals create original product designs, and communities of users select and adopt designs without the use of market transactions.

The availability of free, socially-produced designs has given rise to a new type of consumer that can make her own products (consumer-creators) without using a traditional market-based exchange system. While we can observe the innovation of new products by social production communities (Benkler 2006), little research has been undertaken to explain the mechanisms that enable the selection of products that are created by these communities. This chapter explores nonmarket innovation phenomena to further our understanding of how consumers select such products. This chapter extends the concept of social production to explicate the concept of community selection as a key mechanism that enables individuals to select nonmarket innovations for their own use. Community selection functions, in part, to evaluate the reputation of individual designers that share their original product designs. The designer's reputation is an indicator of standing within the community that spills over onto the expected quality of the product designs and, thus, sways individuals' product selection decisions.

This chapter utilizes a multi-method approach that combines secondary data with behavioral lab data to empirically test hypotheses that product design attributes influence the extent that users select designs that are generated via nonmarket innovation. Further, the data are used to empirically test hypotheses that the designer reputation moderates the likelihood of individual user selection of nonmarket innovations. This essay makes theoretical contributions by introducing the social production perspective to the marketing literature, incorporating the evaluation mechanism of community selection, and suggesting the relevance of the social production perspective for understanding how users select designs that are created via nonmarket innovation. This essay has managerial implications for firms that seek to understand and learn from social production

communities, which are an underutilized domain of external knowledge for generating novel product designs. An improved understanding of these nonmarket innovation mechanisms provides insight that benefits consumers who participate in social production. Additionally, these insights offer lessons to firms that can learn about such forms of open innovation that threaten their traditional businesses.

Throughout this dissertation, there is a common theme of empirically testing the various outcomes of open innovation. One deficiency of research in the open innovation domain is that there is a lack of empirical measures that assess the performance outcomes of open innovation paradigms. To date, the research on open innovation research has relied heavily upon case studies and anecdotal information from companies such as Intel and P&G (Dahlander and Gann 2010). As an emerging research area, the extant empirical research on this topic is limited and fragmented (Dahlander and Gann 2010). Consequently, there is a need for empirical research that links open innovation to performance outcomes with managerial implications for practice (West, Vanhaverbeke, and Chesbrough 2006). As a result, an overarching goal throughout this dissertation is to empirically link performance outcomes with open innovation to provide a solid foundation to contribute to theoretical development in this domain in addition to offering evidence-based managerial insights. Finally, chapter 5 concludes this dissertation by summarizing the contributions of this research and suggesting future research directions.



## **Chapter 2**

### **Literature Review**

#### **2. Introduction**

In order to unpack the mechanisms that enable open innovation's effect on innovation outcomes, a necessary first step is to clearly understand what exactly comprises open innovation. This chapter reviews existing literature on open innovation to evaluate its limitations and discover gaps that can serve as research questions for this dissertation. The focus is on explaining the types of open innovation with two purposes: 1) to delineate the differences and relationships between the various forms of open innovation, and 2) to integrate them into a common framework. As a result, the framework reveals opportunity areas to further explore how firms and individuals utilize open innovation paradigms to achieve new product success.

#### **2.1 A Firm Centric, Knowledge Perspective of Open Innovation**

The term "open innovation" was coined by Chesbrough (2003a), and its core meaning originates from his perspective. Broadly defined, the phenomena of open innovation include business models, strategies, and processes that leverage "purposeful inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (Chesbrough 2006). His vision conceives open innovation from a firm-centric perspective. It attempts to explain how freely available external knowledge can be internalized by firms in their efforts to develop new products, and how the internal knowledge that is accumulated by firms can be externalized through nontraditional channels (Chesbrough and Appleyard 2007; Laursen and Salter 2006).

Chesbrough's firm-centric definition of openness relies on the principal notion of organizational permeability (Baldwin and von Hippel 2011). In other words, a critical assumption of this view of open innovation is that the boundaries of the firm are porous such that ideas can move freely into and out of the firm without being bounded by rigid controls over intellectual property (Chesbrough 2003c). Chesbrough's perspective assumes a weaker role of intellectual property compared to closed innovation models that rely more heavily on patenting and protecting innovations that are developed internally (Almirall and Casadesus-Masanell 2010). Such firms that develop new products through closed NPD processes have also been described as "producer innovators" because they innovate without collaborating externally and have exclusive control over the resulting intellectual property (Baldwin and von Hippel 2011). In contrast to producer innovators, Chesbrough (2006) emphasizes the permeability of NPD processes in open organizations, who seek to absorb external knowledge as well as to accelerate internal knowledge to atypical external markets.

Another tenet of this view of open innovation is that firms should concentrate on analyzing and harnessing knowledge flows (Cassiman and Veugelers 2006; Chesbrough 2006). From this knowledge-oriented perspective, firms actively search for knowledge externally, absorb external knowledge, create knowledge internally, combine external knowledge with internal knowledge, and transform knowledge into innovations that should be accelerated to the marketplace (Chesbrough 2006). The focus is on identifying external knowledge spillovers that can be harnessed by the firm's innovation process. From this perspective, firms should utilize the external knowledge to create innovations that can be sold to customers at a profit for the benefit of the firm that takes the innovation to market. In the same manner, firms are encouraged to seek

opportunities to externalize their own underutilized knowledge that is not immediately commercialized as new products (Chesbrough 2003a).

Due to the emphasis on managing knowledge flows in this area of open innovation, existing studies tend to focus on the research and development (R&D) activities of firms. Open innovation paradigms are often compared to traditional closed innovation approaches in which firms make all of their own choices and rely on their internal R&D resources when creating new products (Almirall and Casadesus-Masanell 2010). Prior to the “era of open innovation” (Chesbrough 2003c), many dominant firms invested in large internal R&D functions. As part of the emerging conceptualizations of open innovation, these large R&D operations were contrasted with smaller, externally focused R&D units (Chesbrough 2004; Chesbrough and Crowther 2006). As such, the attention of academic researchers in this area has been on R&D because of the assumption that R&D is the central organizational function that searches for, acquires, and transforms knowledge during the NPD process (Chesbrough 2006; Chesbrough and Crowther 2006; Laursen and Salter 2006; Leiponen and Helfat 2010). Consequently, much of the research in this domain is based upon the firm centric, R&D-focused, knowledge perspective of open innovation (Chesbrough 2006).

## **2.2 A Firm Centric, Inbound-Outbound Perspective of Open Innovation**

As researchers attempt to further delineate what is and is not included within the domain of open innovation, the knowledge perspective naturally gives rise to the inbound knowledge versus outbound knowledge dichotomy (Bianchi et al. 2011; Chesbrough and Crowther 2006; Gassmann and Enkel 2004). The most fundamental aspects of firm centric open innovation are inbound and outbound knowledge transfer, where innovative ideas flow in and out of the focal

firm (Bianchi et al. 2011; Gassmann and Enkel 2004). This broad classification has been referred to as outside-in (inbound), inside-out (outbound), and coupled processes, which exhibit a combination of inbound and outbound knowledge transfer (Enkel, Gassmann, and Chesbrough 2009).

Inbound open innovation pertains to how firms source, screen, evaluate, acquire, and leverage external knowledge resources for their innovation processes (Dahlander and Gann 2010). Inbound open innovation phenomena are among the most frequently researched aspects of open innovation. Some examples of such external knowledge sourcing include using knowledge brokers (Chesbrough 2003b), engaging in crowdsourcing (Ebner, Leimeister, and Krcmar 2009), appropriating external ideas (Rigby and Zook 2002), and integrating customers and suppliers into a firm's NPD process (Leiponen and Helfat 2010). A classic example of inbound open innovation is P&G's Connect + Develop program, which orchestrates the solicitation and internalization of external contributions from its global knowledge network of customers, suppliers, universities, and other external inventors (Huston and Sakkab 2006).

Outbound open innovation refers to how a firm systematically externalizes its internal ideas and innovations through nontraditional channels rather than directly commercializing its internal ideas and innovations through familiar markets (Dahlander and Gann 2010). Outbound open innovation examples include revealing, selling, or licensing intellectual property that is internally generated by the firm, exploiting ideas in different markets, and multiplying technology by transferring ideas to the external environment (Almirall, Casadesus-Masanell 2010; Enkel, Gassmann, and Chesbrough 2009). For example, a firm may sell exclusive rights to its technology through a patent or license, or it may offer its technology to users and outside innovators at no charge in hopes that its technology will become the foundation for further

innovations. The pharmaceutical industry is especially adept at the outbound process, as it has a tradition of developing medicines that are targeted for a particular condition but that become more successful when applied to other ailments. From this perspective, the locus of innovation is maintained inside the focal firm's R&D function, and open innovation serves to commercialize those innovations by transferring them outside the firm through nontraditional channels. In this manner, the NPD process is closed during idea generation and development, while the outcome is open during commercialization (Huizingh 2011).

The two fundamental categories of inbound and outbound open innovation allude to an organization's broad external orientation and a purposeful effort to commercialize new products through an open NPD process. This focus on harnessing inbound knowledge and outbound knowledge originates from a firm centric perspective. Further, the inbound and outbound dimensions stem from an R&D centered view of how knowledge flows should be managed. However, the phenomena that comprise open innovation are significantly more complex than a simple choice to be open in terms of an inbound versus outbound dichotomy (Acha 2007). Not all forms of open innovation are comprised of firms coordinating and controlling the use of knowledge. In contrast, the following section discusses a non-firm centric perspective of open innovation in which individuals and communities of individuals collaborate to innovate without the supervision and direction of a governing organization.

### **2.3 A Non-Firm Centric, Knowledge Perspective of Open Innovation**

Baldwin and von Hippel (2011) define open innovation as the collaborative sharing of the work of NPD among individuals. These contributors are often consumers of the new product, but they can also be other users who are interested in developing the product even if they are not

direct consumers of it. Further, this perspective of open innovation includes innovation by collaborative, knowledge-sharing communities in addition to innovation by individuals (Boudreau and Lakhani 2009). Lead users are a notable example of non-firm centric open innovation because they innovate independently, and with other consumers of the same products, in order to find a solution for their own product needs prior to firms supplying a product for the broader marketplace (Franke, von Hippel, and Schreier 2006).

A central notion of non-firm centric open innovation is that the contributors are self-managed, and they organize their efforts through communities of users who exhibit shared interests around developing the product (O'Hern and Rindfleisch 2010). An example of such innovation is open source software, which depends on the voluntary contributions of individuals who share their expertise with the project's community (Mallapragada, Grewal, and Lilien 2012). These communities are sometimes referred to as "distributed innovation" systems and display product development activities that are characterized by self-selected participation and decentralized decision-making (Lakhani and Panetta 2007). The main idea is that the innovation process is initiated and conducted by individuals who self-organize outside of the governance and control of a firm.

Since this approach to open innovation is not directed by a profit-seeking firm, there is substantially less apprehension from the innovators that other individuals might use their contributions free of charge. In contrast, firms and their managers are especially concerned with appropriation of their own innovations because appropriation directly relates to their firms' financial performance. They may express indifference, or even discouragement, towards firm-led activities to develop innovations that become public goods.

However, the non-firm centric perspective defines the outcome of open innovation as publicly shared. “Openness” is described in terms of purposefully reducing restrictions on the use, development, and commercialization of an innovation (Boudreau 2010). Experts are encouraged to be transparent in sharing and reusing each other’s knowledge in a manner that facilitates the contributions of additional participants (Lakhani and Panetta 2007). The proponents of this approach to open innovation emphasize the nonexclusive, shared nature of the innovation intellectual property output, which they advocate to be voluntarily given up as a nonexcludable public good (Baldwin and von Hippel 2011).

This view of open innovation is especially common among open source software projects, in which the individuals that develop the software typically offer their collective innovations freely for public accessibility by all (Baldwin and von Hippel 2011; Boudreau and Lakhani 2009; Mallapragada, Grewal, and Lilien 2012). This perspective asserts that individuals collaborate through communities in order to solve problems related to the product, and to exchange and freely share their own contributions. This communal behavior occurs without any expectation that voluntary contributors will be able to profit from their individual or collective innovation efforts (von Hippel and von Krogh 2003).

The firm centric and non-firm centric definitions are dissimilar from each other, yet they both succeed in capturing different aspects of open innovation. Each definition has merit because it adds to our understanding of the various phenomena of open innovation that are emerging in practice. Yet because these perspectives are conceptually divergent, there remains some confusion as to what exactly is included within the domain of the term “open innovation.” Therefore, the following section attempts to integrate these different perspectives by proposing an alternative framework that helps to organize the diverse approaches to open innovation.

Subsequently, this dissertation contains chapters that will apply the proposed framework to investigate mediating mechanisms that enable new product performance outcomes from the firm centric perspective, and explore the individual user selection of products that are created from non-firm centric communities of open innovation.

## **2.4 An Integrative Framework of Open Innovation**

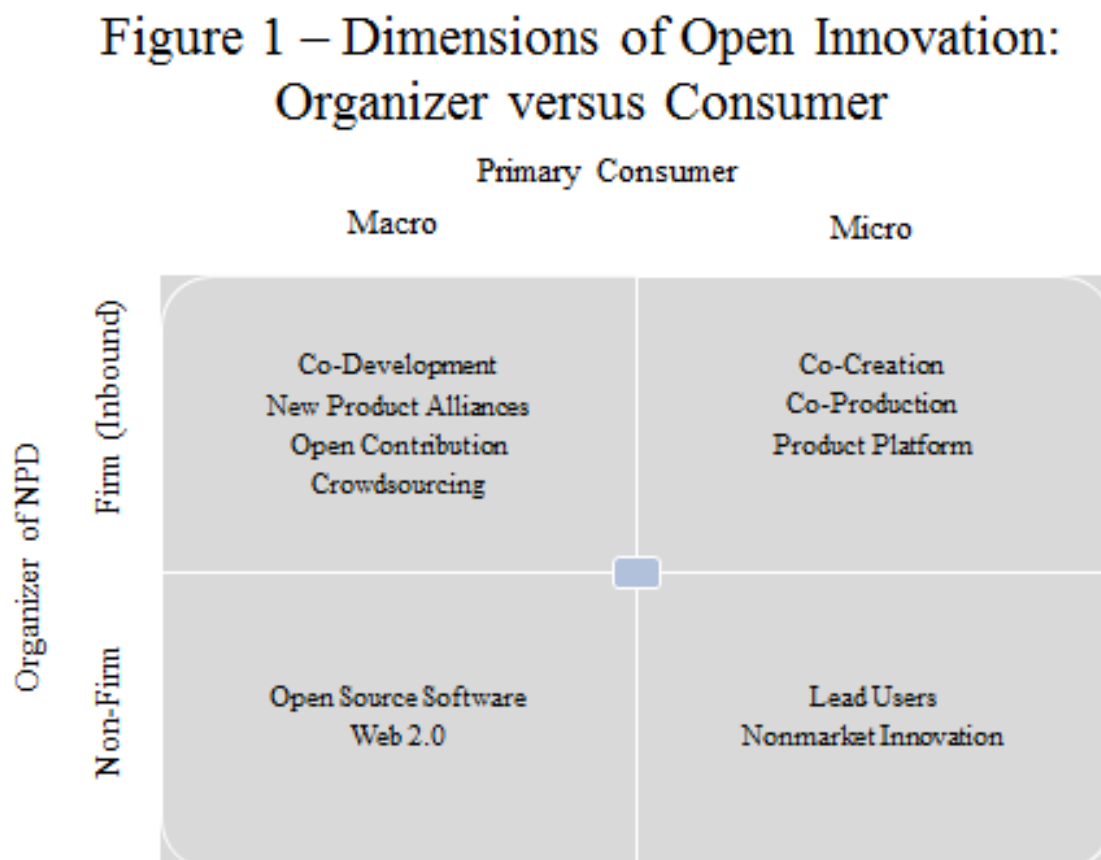
“Open innovation” has evolved to become an umbrella term that encompasses numerous disparate forms of collaboration between firms and individuals that seek to create new products. To improve our understanding of these widely-varied approaches, this dissertation offers an integrative framework that delineates the commonalities, differences, and relationships between these numerous forms of open innovation. In particular, despite the noted dissimilarities between the firm centric and non-firm centric views, there is another difference between types of open innovation that is understated in the extant literature: the consumption of products that are created via open innovation activities.

The consumption of products that are created via open innovation is an important element of this discussion because knowing who uses the end product helps to shape and define the type of open innovation that is used to develop the new product. For example, while contributors to open source projects may be intrinsically motivated to offer their expertise freely, they may benefit extrinsically because they are also frequently end users of the resulting product (Mallapragada, Grewal, and Lilien 2012). In contrast, many firms lead open innovation efforts because they expect to sell the resulting product to consumers and/or other organizations (Dahlander and Gann 2010). Whether organizational or individual, such contributors to firm centric open innovation activities may expect to receive some extrinsic reward for their



participation. The question of how to motivate these various types of contributors leads to differences in how the innovation activities are organized.

Thus, the distinction in the consumption of the new product output is notable because it influences how various stakeholders are motivated to be engaged in the innovation process, and it shapes how firms and individuals will decide to organize the innovation activities. Therefore, this dissertation conceptualizes an integrative framework of open innovation that is based upon two key dimensions: 1) the organization of the NPD activities to create an innovation, and 2) the primary user of the innovation output upon its creation. This framework is depicted in Figure 1.



The first dimension, organization of NPD activities, examines who organizes, or governs, the NPD effort that take place with open innovation. As discussed above, the major definitions of open innovation contain notable differences in their meaning, depending upon whether they originate from a firm centric or non-firm centric perspective. The non-firm centric perspective of open innovation focuses on individuals and communities of users that self-organize a public NPD process, while the firm centric perspective of open innovation emphasizes firms' efforts to purposefully manage the inflow and outflow of knowledge across the permeable boundaries of their own NPD processes. The firm centric perspective analyzes the knowledge accumulated and managed by the R&D function as organized by firms, whereas the non-firm centric view examines the knowledge of individuals that is leveraged independently or shared through user communities.

Firm centric open innovation assumes that the firm organizes the production of the innovation outcome, while non-firm centric open innovation assumes that individuals or communities of individuals produce the new product. Naturally, the firm centric view is more concerned with protecting its intellectual property at a profit while the non-firm centric view advocates nonexcludable public use of innovations that arise from shared, voluntary development efforts. Because of the importance of the division in the organization of open innovation activities, the first dimension of firm centric versus non-firm centric organization is retained in the integrative conceptual framework.

For the second dimension, the framework delineates the primary consumption activities into macro consumption and micro consumption. With macro consumption, products are developed via open innovation with the intention of the product being utilized by numerous consumers. This outcome occurs when it is assumed that the NPD process is separate from the

consumption process. For example, firms may solicit ideas from customers but still develop the idea through their own proprietary closed process (O'Hern and Rindfleisch 2010). The innovation is developed and produced, and then the finished product is sold to customers through transactions that are subsequent and separate from production. Similarly, with some community-organized innovation efforts, such as open source software, the product is developed by a relatively limited group of technical experts whereas the finished product is consumed subsequently by a much larger group of users (von Hippel and von Krogh 2003). The product can be made publicly available at no charge, as in the example of non-firm centric development of open source software, or it may be offered to the general public at a price, as is the case with most goods that are developed by firms for large scale production.

But with some forms of open innovation, products are developed primarily for micro consumption by an individual consumer. Generally, micro consumption occurs with types of open innovation where NPD efforts take place concurrently with the product's consumption, as is the case with lead user innovation (von Hippel 2005). Lead user innovation is completed by individuals and communities that develop a new product and innovate simultaneously as they consume the product, despite a lack of governance of the innovation process by an organizing firm. This method involves development of a new product by an individual for that user's specific consumption. With micro consumption forms of open innovation, the boundaries between NPD and consumption are blurred because innovation and use occur concurrently.

While lead user innovation is completed by individual consumers, other approaches to open innovation, such as customer co-creation, are organized by firms with the goal of joint creation of new products by customers and firms (Prahalad and Ramaswamy 2002). This tactic enables users to customize the firm-supplied product to meet their own unique preferences. More

examples of the various approaches to open innovation are described below. The next section delineates specific types of inbound open innovation that are organized by firms in which the resulting new product is intended for macro consumption, as depicted in quadrant 1 of Figure 1.

## **2.5 Quadrant 1: Firm Centric Inbound Open Innovation with Macro Consumption**

This quadrant captures specific types of open innovation in which the NPD process is organized by firms, and where the resulting new product is intended for macro consumption. The scope of this review is limited to approaches of inbound open innovation in which firms search for external knowledge to aid their development of innovations. This section highlights four popular categories of open innovation that fall into quadrant 1: co-development, new product alliances, open contribution, and crowdsourcing. A brief overview is provided to describe each approach to open innovation and explain why it falls into this quadrant.

### **2.5.1 Co-development**

Some innovation networks operate like private clubs in which specific members are invited by a firm to solve problems for a particular innovation project (Knudsen and Mortensen 2011). These open innovation projects tend to be hierarchical because they are led by and controlled by the firm (Pisano and Verganti 2008). New product co-development is one such mode of hierarchical collaboration. Co-development restricts external participation by involving a mutual working relationship between a limited number of partners (frequently, only two firms) with the specific purpose of creating a new product (Chesbrough and Schwartz 2007). From this perspective, open innovation attempts to use the right mix of internal and external resources to

enable co-development of new products by two or more collaborating firms (Emden, Calantone, and Droge 2006).

With co-development, NPD becomes a joint problem-solving process in which each partner executes a significant portion of the development tasks (Fang 2008). While the co-development collaboration is nonequity-based, the stakeholders work together during NPD because they have a shared interest in the success of the innovation outcome (Emden, Calantone, and Droge 2006). This collective interest is often the result of an existing interdependence between stakeholders (Lengnick-Hall 1996), as is the case where suppliers and their organizational customers rely on each other's success to support their mutual prosperity. An example of this co-development interdependence is the manner in which Dell is closely involved in its key suppliers' development of new products (Fang, Palmatier, and Evans 2008). Since the partners are each expected to contribute substantially to the development of an innovation, there is typically a high level of transparency and frequent interactions during co-development activities until the project is complete (Emden, Calantone, and Droge 2006; Lengnick-Hall 1996).

### **2.5.2 New Product Alliances**

Similarly, new product alliances are akin to co-development relationships, but they have three notable differences. First, new product alliances have formalized arrangements. At a minimum, this formalization may include registering the alliance with the appropriate governing body (Rindfleisch and Moorman 2001; Swaminathan and Moorman 2009). At a greater level of formalization, a more hierarchical governance form could include shared equity between firms, which would indicate that the new product alliance is an equity-based joint venture (Lee 2011).

Second, new product alliances involve frequent interactions and often accumulate interdependent resources over the course of jointly working on numerous new product projects (Ma, Yang, Yao, Fisher, and Fang 2012). In contrast, co-development often focuses on the development and completion of one specific new product. Third, the intent of new product alliances is to increase information sharing and jointly acquire knowledge related to R&D (Rindfleisch and Moorman 2001). As such, a key goal of new product alliances is learning from partners' resources and capabilities, but not necessarily with the intent to complete development of a specific new product as in the case of co-development.

### **2.5.3 Open Contribution**

Open contribution is an organization-led phenomenon in which external stakeholders can actively provide their input to an organization's internal NPD process (O'Hern and Rindfleisch 2010). From a firm's perspective, open contribution describes the efforts of the organization to extensively search for and acquire external knowledge, and to involve external stakeholders in its NPD process (Acha 2007). This collaborative perspective typically emphasizes cooperation with external stakeholders and the development of multiple channels to absorb external knowledge in order to accumulate learning and innovation (Belussi, Sammarra, and Sedita 2010).

While the previously discussed new product co-development and alliance approaches to open innovation restrict the number of participants in the NPD process, open contribution significantly widens the scope of outsiders who can potentially contribute to a firm's innovation activities. O'Hern and Rindfleisch (2010) describe open contribution as external individuals submitting content to a firm for consideration, to possibly be developed into a new product by the firm. Since external knowledge is increasingly abundant (Chesbrough 2003a), open

contribution emphasizes an inbound flow of knowledge through a firm's external search process to identify and gather diverse ideas during NPD (Gassmann and Enkel 2004). This perspective expands the scope of participants in the NPD process beyond customers and suppliers, since external stakeholders can include inventors and other outside entities that are interested in the product but may not consume it or directly benefit financially from the product's consumption by others.

Open contribution is also distinct from other forms of open innovation because it is a one-way process in which the firm receives information from the environment for input into its NPD process. For example, P&G's approach to open innovation is fundamentally based on the idea of open contribution, where the firm actively seeks solutions to its customer needs from external contributors (Dodgson, Gann, and Salter 2006). While the contribution process may be open, P&G's internal employees still evaluate external ideas on the basis of market potential and technical feasibility. As a result, P&G retains control over selecting which ideas it will develop into new products. Thus, open contribution is distinct from other forms of open innovation in that the firm still utilizes internal mechanisms to retain control over choosing the external content to be used in the development of a new product (O'Hern and Rindfleisch 2010). Similarly, other NPD activities, such as development, testing, and commercialization, might still be led internally or completely controlled by the organization.

In particular, the firm's search activities of open contribution scan the environment for outsiders to provide ideas and technologies during NPD with a specific intent to commercialize the new product output (Boudreau and Lakhani 2009; Laursen and Salter 2006). This is because, to operate successfully in an open environment, the focal firm benefits from retaining control of the intellectual property solutions (Alexy, Criscuolo, and Salter 2009). Correspondingly, P&G

maintains the right to appropriate value from the new product via commercialization or other means. Thus, open contribution is a much narrower facet of the more general concept of open innovation because open contribution still allows the firm to control its activities of selection, development, testing, and commercialization of new products. The flow of external knowledge into the firm via open contribution is the predominant area of extant research on firm-organized inbound open innovation.

#### **2.5.4 Crowdsourcing**

While most approaches to open innovation emphasize external collaboration, other forms of inbound open innovation emphasize the use of competition to leverage external knowledge. This open competition style of innovating is represented by the term “crowdsourcing.” With crowdsourcing, firms outsource idea generation tasks at the front end of their NPD processes to a loosely defined group of outsiders in the form of an open call for creative solutions (Bayus 2013). Typically, organizations post an innovation problem that has clearly-defined boundaries, specific objectives, and measurable outcomes for the new product idea submission activities. That is, the firm normally controls the scope of the innovation project and often completes or, at a minimum, administers the new product selection process.

Organizations use a crowdsourcing strategy to disperse their innovation problems widely in an attempt to find solutions via the “wisdom of crowds” (Alexy, Criscuolo, and Salter 2009; Surowiecki 2005). This approach encourages a greater heterogeneity of knowledge working on the innovation problems, which can be an effective approach when the innovation problems can be solved best by broad experimentation (Boudreau and Lakhani 2009). For example, the open broadcast of innovation problems serves to engage external solvers that use their fresh



perspectives to submit highly successful ideas even if they originate from separate, distant bases of technical expertise (Jeppesen and Lakhani 2010). As such, creative problem solving tasks that were traditionally completed by internal experts comprised of professional marketers, engineers, and designers, are replaced with a dispersed crowd of non-expert outsiders (Bayus 2013; Poetz and Schreier 2012).

With crowdsourcing, the call for idea submissions is organized as a design contest in which contributing ideas compete against each other (Boudreau, Lacetera, and Lakhani 2011). The soliciting firm awards the best design among the pool of new product idea submissions with an extrinsic reward, an intrinsic reward, or a combination of both. But there is typically only one designated winner at the end of the competition (Poetz and Schreier 2012). By offering a reward for the best new product idea, firms pit competing contributors against each other since there can only be one winning idea. In this manner, open innovation strategies that utilize a competitive markets approach encourage external innovators to develop competing varieties of products, which often discourages cooperation (Boudreau and Lakhani 2009). Further, there are cases of even more complex crowdsourcing contests that have evolved to become “innovation tournaments,” which engage external new product ideas in multiple rounds of competition until a surviving winner emerges (Terwiesch and Ulrich 2009).

Thus, while some forms of open innovation emphasize transparency and collaborative engagement of external stakeholders, crowdsourcing uses a market mechanism to search for and acquire external knowledge from diverse sources to solve internal innovation problems (Jeppesen and Lakhani 2010). Some firms operate one-time contests, which can be administered directly by the soliciting firm, or through contracted third-party knowledge brokers, such as Innocentive (Chesbrough 2003b). Other firms, such as Dell’s IdeaStorm initiative, cultivate

communities of external solvers who submit ideas repeatedly over time (Bayus 2013). With both approaches, a firm organizes the open innovation activities by leveraging a competitive market mechanism to elicit innovation. Further, the new product is developed for macro consumption, which does not occur until after the crowdsourcing contest has closed and the winning idea has been developed and produced by the organizing firm.

## **2.6 Quadrant 2: Firm Centric Inbound Open Innovation with Micro Consumption**

Quadrant 2 contains specific types of inbound open innovation in which the NPD process is organized by firms, and where the resulting new product is innovated primarily for micro consumption. Next, three prevalent categories of open innovation are highlighted that fall into quadrant 2: customer co-creation, customer co-production, and product platform models. A brief overview is provided to describe each approach and to explain why it falls into quadrant 2.

### **2.6.1 Customer Co-creation**

Prahalad and Ramaswamy (2000) coined the term customer “co-creation” to mean the joint construction of product value by customers and a firm. This perspective centers on consumers as an integral part of product value creation, such that they influence “where, when, and how value is generated” (Prahalad and Ramaswamy 2002). Further, customer co-creation focuses on the expanded role of customers as collaborating, creating, and extracting product value (Prahalad and Ramaswamy 2000; 2004b). These authors observe that consumers exhibit an increasing ability and willingness to experiment with the development of new products (Prahalad and Ramaswamy 2002). As such, co-creation emphasizes the transition of customers from a

formerly passive consumption role to an active collaboration role in NPD (Prahalad and Ramaswamy 2004a).

During the value creation process, there are multiple points of interaction in which individuals can co-create value with the firm (Prahalad and Ramaswamy 2002). Under co-creation, empowered customers take an active role in designing and selecting innovative ideas during a firm's process of developing new products that the same customers buy and use (O'Hern and Rindfleisch 2010). An example is Threadless, which is an apparel company that features original graphic designs that are created by its customers. Individual designers submit their digital designs to Threadless, which publicly posts the designs for other members of the customer community to view. The community rates the designs to determine which ones will be selected for printing. As a result, the new product co-creation is a function of this ongoing interaction between customers and the firm (Grönroos and Voima 2013). This critical interaction between individuals and firms is the locus of innovation that replaces the traditionally closed forms of innovation that previously resided within organizations (Prahalad and Ramaswamy 2004b).

The value co-creation process may be more appropriately described as value "formation" or value "emergence" to emphasize the innovative nature of co-creation, and to distinguish it from more routine product delivery methods such as the customer self-service tasks that occur as part of customer co-production (Grönroos and Voima 2013). In contrast, the unique preferences of individual users and their heterogeneous demands are central to the customer co-creation experience (Prahalad and Ramaswamy 2004a). In particular, co-creation seeks to jointly create content of personalized experiences for customers (Prahalad and Ramaswamy 2000). As such,

co-creation emphasizes accessibility and transparency in firms' interactions with customers (Prahalad and Ramaswamy 2004b).

### **2.6.2 Customer Co-production**

Customer co-production refers to the involvement of customers in the delivery and customization of products that are initiated and designed by firms. Bendapudi and Leone (2003) define co-production as customer participation with firms in the joint provision of products. In other words, the firm manages the creation of value and invites the customer to produce the product together with the firm. Mass customization is one example of co-production in which the firm manages the value creation process, but the customer can actively participate in the process by tailoring the product to her individual preferences. With mass customization, the firm offers a menu of predefined parameters that a consumer can choose from in order to configure the product according to her specific needs (Liechty, Ramaswamy, and Cohen 2001). Thus, the firm facilitates the creation of mutual value that consumers customize to their own heterogeneous preferences during production (Payne, Storbacka, and Frow 2008).

The notion of customer co-production is closely associated with service-dominant logic (SDL) theory (Vargo and Lusch 2004). SDL theory includes a foundational premise that describes the important role of value co-creation, which is now stated to comprise both the co-creation of value as well as the co-production of the product (Vargo and Lusch 2008). From this perspective, the value of a product is determined by the user during the consumption process. The co-creation aspect of this process is determined by the "value-in-use" (i.e. consumption) of the product, while the co-production component of this process is indicated by consumers'

participation in the formation and delivery of the actual core product offering (Lusch and Vargo 2006).

### **2.6.3 Product Platform Models**

There are two approaches to utilizing the product platform business model. The first approach is to grant outsiders the ability to access internally developed intellectual property, which enables external innovators to develop complementary products that are compatible with the platform (Boudreau 2010). A well-known example is Apple's iPhone. The iPhone was developed through a proprietary innovation process, but Apple permits sufficient access to the operating system such that external innovators are able develop applications and other forms of electronic content (Boudreau and Lakhani 2009). The product applications are typically generated by users who consume the content as they create it. In this manner, granting access to the product platform opens up markets for complementary product development (Boudreau 2010).

The second approach to utilizing the product platform business model is to relinquish some control of the product platform itself in order to encourage innovation to be built around the platform. This tactic removes restrictions on the outside use, development, and commercialization of portions of the product platform system or its subcomponents (Boudreau 2010). This approach often results in a reduction in NPD costs as well as an acceleration in the speed of both product development and product diffusion (West 2006). The simultaneous acceleration in innovation and diffusion occurs because external innovators are able to use the product as they develop it.

## **2.7 Quadrant 3: Non-Firm Centric Open Innovation with Macro Consumption**

There are other types of open innovation that are not organized by firms. Since these approaches do not originate from the firm-centric perspective, they are classified as neither inbound nor outbound. Instead, they are referred to as self-organized, actor-oriented modes of collaboration (Fjeldstad, Snow, Miles, and Lettl 2012). This approach to open innovation is broadly described as “social production” (Benkler 2006).

Social production is a form of innovating in which individuals and loosely connected communities of individuals create new products through voluntary contributions without the oversight of a formal governing body (Benkler 2006). Social production stands in contrast to conventional market-based production models that are traditionally preferred by “producer innovators” (Baldwin and von Hippel 2011) in which goods are manufactured and distributed by firms. Social production can include both “peer production” and independent nonmarket production (Benkler 2006), which will be discussed further in section 2.8.

Peer production is a system of innovating among large groups of individuals who collaborate to develop new products without utilizing traditional market transactions for knowledge exchange or firm governance for organizing and directing their innovation activities (Benkler and Nissenbaum 2006). With peer production, the new product that is developed through the community-organized innovation effort is made available for consumption by the general public. In other words, after the development of a new product has progressed to a functional form, it is subsequently adopted by a greater number of users. This section expands the discussion of two popular forms of the peer production approach to open innovation, open source software and Web 2.0 platforms, and it explicates how each type falls into quadrant 3.

### **2.7.1 Open Source Software**

The most well-known, and most heavily researched, type of peer production is open source software (OSS). OSS projects are Internet-based product development activities that are jointly completed by voluntary communities of software experts (von Hippel and von Krogh 2003). OSS innovation is an example of collaboration that occurs completely beyond the boundaries of the firm (O'Hern and Rindfleisch 2010). Such projects are led by innovation network communities that are characterized as being open and flat (Pisano and Verganti 2008). This loose structure is quite different from the firm-centric modes of open innovation in which an orchestrating firm organizes and directs much of the innovation activities. The wide recognition and popularity of open source products is partly due to the emergence of OSS communities in the 1960's and 1970's (von Hippel and von Krogh 2003), which long predates the relatively recent trend of firm centric open innovation.

The OSS culture encourages individuals that collaborate on software projects to have a "stated ethos" to allow volunteers to develop source code without constraints of any formal hierarchy (Crowston et al. 2005). Projects reflect this unrestrictive spirit by attempting to make it easy for individuals to provide software code and ideas without obtaining special development tools or permission from a centralized governing organization (Lundell, Persson, and Lings 2007). At its roots, this philosophy advocates giving up control of both the process of NPD and over the individual developers who write software code for the project (Crowston et al. 2005).

A hallmark of OSS phenomena is that the developers typically allow the resulting intellectual property to be made freely available to the general public without concerns for value appropriation (Alexy, Criscuolo, and Salter 2009; Dahlander and Gann 2010). Innovation appropriability is a new product developer's ability to capture the value created by the innovation

and to minimize the risk that unprotected innovations are leaked to competitors (Dhanaraj and Parkhe 2006). OSS projects especially encourage cooperation, open access to information, joint development of products by communities, and free sharing of the resulting intellectual property to all future users (Boudreau and Lakhani 2009; Gassmann and Enkel 2004; von Hippel and von Krogh 2003).

However, this open access to the resulting innovation output does not equate to unlimited access to freely modify and contribute to the development of the innovation. As an OSS project progresses to the stage of testing and validation, it often reaches a point where it is determined to be of sufficient quality by the lead project maintainers such that the current state of the project becomes the authorized version of the code. Access to modifying or adding to the authorized code becomes restricted to only a few trusted individuals who have amassed a credible reputation from their accumulated participation in the project's development (von Hippel and von Krogh 2003). Moreover, research on OSS communities suggests that the social capital held by project managers enables them to invite individual developers to contribute to projects and that their relational embeddedness has a strong effect on the resulting innovation output's success (Grewal Lilien, and Mallapragada 2006).

This distinction between restricted access to the NPD process and open access to consume the resulting new product is important because it indicates that the development of the new product is frequently targeted for macro consumption. An OSS project typically has a formal product release in which the innovation is moved from a relatively small community of developers and opened to a much wider audience of users (Mallapragada, Grewal, and Gary Lilien 2012). This difference between NPD and consumption suggests that only certain technical experts, who have amassed sufficient reputation within the OSS project community, are



permitted to participate in the actual development activities while the vast majority of users of OSS products are essentially free riding consumers (von Hippel and von Krogh 2003). The dissimilarity in open innovation perspectives demonstrates how open innovation can be either pecuniary, as is the case with hierarchical firm-led projects that commercialize innovations generated by outsiders, or non-pecuniary, as is the case with OSS communities in which the resulting products are made freely available to the general public (Dahlander and Gann 2010).

### **2.7.2 Web 2.0 Platforms**

Another approach to peer production includes the phenomena of individual innovators that participate in Web 2.0 platforms. Web 2.0 content is created by a collaborating community of innovators that share a common interest around a particular topic, collectively contribute to the development of the content, and concurrently consume the innovation outcome. Examples of such platform communities include Wikis, YouTube, Facebook, Google Maps, podcasts, and community blogs (Hoegg, Martignoni, Meckel, and Stanoevska-Slabeva 2006). Web 2.0 platforms are centered around the collaborative sharing of knowledge that is focused on topics of interest to each particular community.

Web 2.0 communities have basic ideals that are similar to OSS cultures in that they advocate free access for the public to consume the products that are created through their communal, voluntary innovation efforts. Consequently, it is often difficult for incumbent actors, such as firms that offer competing products at a profit, to gain acceptance among the contributor community as potential participants in the content development process that occurs through Web 2.0 platforms (Hoegg et al. 2006). Thus, Web 2.0 platforms are organized outside of the boundaries and control of firms.

In contrast with OSS projects that typically require individuals to have a sufficient level of technical expertise to make contributions, Web 2.0 platforms are built upon user-friendly applications that hide programming languages and enable non-technical users to create, modify, and upload new content (Hoegg et al. 2006). For example, the Wiki markup language authorship tool permits multiple participants to contribute to the same document without controlling access to editing. Rather, Wikipedia relies on open discourse between contributors in order to develop content and to reach consensus (Benkler and Nissenbaum 2006). This accessible interface enables a wider range of involvement of potential users to contribute content to Web 2.0 platforms rather than relying on a relatively small number of expert developers, as is often the case with OSS projects.

As such, users are able to modify and generate new content at the same time that they consume the existing content. Typically, Web 2.0 platforms contain self-regulation mechanisms for ongoing trust building activities that are completed by community members, such as discouraging or recommending content through rating and voting systems (Hoegg et al, 2006). Thus, users can choose to participate in the innovation process by reviewing, evaluating, and recommending content as they consume it. This form of user participation serves to improve the quality assurance of the innovations generated by the community, even if such contributors are not actually creating new content (Hoegg et al. 2006). As a result of the various options for participation available to users, there is an increased opportunity for involvement by community members in the NPD process. Moreover, this approach enables the product content to continuously evolve and adapt to changing consumer needs.

## **2.8 Quadrant 4: Non-Firm Centric Open Innovation with Micro Consumption**

The last group of open innovation modes, which are depicted in quadrant 4 of Figure 1, includes approaches that are not organized by firms and for which the innovation outcomes are targeted primarily for use by individuals. Specifically, this literature review focuses on two types of non-firm centric open innovation intended for micro consumption: lead users and nonmarket innovation. This section explains how these forms of innovation occur independently with respect to both NPD and consumption.

### **2.8.1 Lead Users**

Lead users are consumers who face product needs months or even years before mainstream consumers (von Hippel 1986). These market leaders are exceptionally adept with the difficult problem-solving steps associated with innovating, and they frequently attempt to innovate to fill their own emergent needs that are unmet by an existing product. Further, they directly benefit by finding a solution to their unfulfilled needs (von Hippel 1986). Lead users benefit through consuming an innovation that they develop, as opposed to producer innovators that benefit from selling an innovation that they develop (de Jong and von Hippel 2009). The importance of this creative group of consumers is evident because innovating users are often strong opinion leaders that positively influence adoption by subsequent consumers and accelerate diffusion of the product (Schreier, Fuchs, and Dahl 2012).

This approach to open innovation relies on a high level of competence and motivation to innovate on the part of lead users because they innovate autonomously, without formal governance of a firm. These users draw upon their own local knowledge to innovate rather than waiting for firms to provide solutions for them (Lüthje, Herstatt, and von Hippel 2005).

Innovations are typically created by independent users, although they often freely share their ideas with like-minded users to build on each other's knowledge (Mahr and Lievens 2012). Thus, lead users often create solutions to their own product needs before organizations are even aware of those emergent needs (de Jong and von Hippel 2009). Many lead user-developed innovations are transferred to firms for commercialization only after a sizable market has emerged for the new product (de Jong and von Hippel 2009).

Specifically, the value to the NPD process that is created by lead users compared to mainstream users is their ability to contribute solutions to innovation problems rather than simply stating existing customer needs. Lead users often exhibit high usage in the product area, gain experiential learning with related products, and develop expertise in the activity in which they use the products (Mahr and Lievens 2012). This experience serves as a foundation for their knowledge of advance market needs (von Hippel 2005). Lead users modify products to meet their own consumption needs and they develop new solutions through their experience with consuming the product as they innovate. As a result, lead users self-organize their innovation activities and individually consume their products concurrently as they develop them.

### **2.8.2 Nonmarket Innovation**

Nonmarket innovation is completed by independent users that design new products to meet their own in needs in the absence of influence by firms. With this type of open innovation, consumption and production are no longer separate economic activities because individual users actively create designs as they consume the product. As a result, these users are sometimes referred to as "consumer-creators" because they consume as they innovate.

Consumer-created innovations identify gaps in existing market offerings that are provided by incumbent manufacturers and retailers (de Jong and de Bruijn 2013). An exemplar is users in three-dimensional (3D) printer communities, who voluntarily create, upload, and share new product designs while bypassing traditional markets, retailers, and manufacturers. Community members are called “makers” because they choose to invent their own products rather than searching for and purchasing a product from a supplying firm. For instance, a popular brand of 3D printer models carries the name MakerBot. Consequently, nonmarket innovators who choose to join “the maker movement” are able to bypass retailers and manufacturers, and their market-based transactions (Rindfleisch 2014).

This approach has been termed “independent nonmarket production” to signal its difference from the traditional, industrial economy production approaches of market-based and hierarchy-based modes (Benkler 2006; Rindfleisch 2014). Independent nonmarket production is not intended for entry into the marketplace in which goods are produced, offered at a price, and exchanged through monetary transactions. Consequently, these individual creative talents are not driven by the prospect of earning profit from their inventions. Instead, according to the theory of social capital, consumer-creators are motivated by social relations to mobilize and share their resources (Benkler 2006).

Nonmarket innovation is different than lead user innovation because lead users typically start with a firm-produced offering as an initial reference point and modify the existing good to create solutions that meet their own emergent needs. In contrast, the maker movement spawns completely new products with original designs that frequently are not based upon an obtainable manufacturer’s design. Thus, independent nonmarket production is completely separated from the traditional, transactional economy. Since nonmarket innovators upload and disclose their

designs freely, they have a lower need for precise information about the content of actions and obligations of actors in comparison to market-based transactional frameworks (Benkler 2006). As a result, consumer-creators have little to no need for the monitoring and enforcement mechanisms that are common in market-based transactional frameworks (Benkler 2006).

Additionally, nonmarket innovation is unique from Web 2.0 platforms for several reasons. First, Web 2.0 platforms facilitate a constant work in progress that is advanced by many users over time. The content on a Web 2.0 platform may never be complete, and it continuously evolves to meet the community's changing needs. However, nonmarket innovators develop completely new products and upload their finished designs. Each design is typically created by an individual that acts independently rather than coordinating innovation sub-tasks through a large community of contributors who work on a central project.

Second, the opportunity for firms to participate in these two self-organized innovation approaches is quite different. Web 2.0 communities typically have a project maintainer who acts as a community moderator in a role that is similar to OSS projects that have a lead developer or project manager. These maintainers are fiercely skeptical of intrusion by firms because they do not want the influence of a profit-motivated organization to discourage the ongoing contributions from individual users that are necessary to enrich and sustain the Web 2.0 platform.

Yet within the independent nonmarket production space, firms have the ability to participate by contributing their own finished designs. The freely available posting of innovative ideas via nonmarket innovation presents an opportunity for forward-looking firms to assimilate novel ideas as well as influence future products that may be adopted by consumers by offering firm-created designs. In other words, professional design firms and established incumbent brands are both beginning to appear in maker movement communities because they are not excluded

from providing their own designs. Since each design is essentially a stand-alone, finished product when it is shared, there is no threat that an incumbent firm can modify the existing content provided by individual contributors. Still, the maker community retains the option to ignore the influence of professional firms by choosing not to download and utilize the firms' designs. However, those designs can remain in the nonmarket innovation space without disrupting the efforts of individuals who continue to create, share, and consume their independently created product designs.

Ironically, companies may choose to build upon these freely-available ideas to manufacture and offer the next generation of products that are of higher quality and/or lower cost than those offerings generated through independent nonmarket production (de Jong and de Bruijn 2013). In particular, the iPhone case is an interesting example because there are consumer-creators designing and selling 3D printed iPhone cases, and Apple is actively buying some of the designs and re-selling them at Apple's retail outlets. This example shows interest from a market leading firm with a large, well-known brand, which increases the relevance of the topic to industry. Moreover, this example validates the reality of potential concerns for competition, opportunity, profit, and the entry of these nonmarket innovations into mainstream traditional retail markets. Thus, nonmarket innovation contradicts the stereotypical "freeware" reputation of many socially produced items.

Paradoxically, this illustration shows that independent nonmarket production not only avoids the traditional transaction-based marketplace, but essentially reverses the traditional market exchange process. With nonmarket innovation, the consumer now invents the initial products, which are subsequently obtained and modified by organizations for resale to other consumers or firms.

## **2.9 Summary of Literature Review**

This chapter has reviewed several popular definitions of open innovation to explain how the concept of “open innovation” has evolved to become an umbrella term that includes numerous forms of collaborative NPD. The review identifies differences among the definitions to reveal the two underlying dimensions of organization and consumption, which are utilized to describe the various styles of open innovation that have emerged in practice. Further, the review offers an alternative framework that integrates the disparate definitions and enables the classification of specific forms of open innovation. The integrative framework is applied to delineate eleven distinct approaches to open innovation, note their differences from each other, describe their commonalities, and identify their relationships with the key dimensions of organization and consumption.

It should be noted that the framework has limitations and is not expected to capture every possible form of open innovation. There are less well-known phenomena that are still emerging in practice, and that will certainly lie beyond the scope of the framework. One such example is crowdfunding (Kuppuswamy and Bayus 2013), which may not fit clearly into one of the four quadrants based upon the dimensions of organization and consumption. Nonetheless, this alternative framework, while not exhaustive, serves to include a high percentage of the more prevalent forms of open innovation.

Further, the integrative framework provides a foundation for this dissertation to explain and predict the various mechanisms that enable the different new product outcomes from various types of open innovation. This dissertation attempts to address specific gaps related to the mechanisms that are needed to leverage the external knowledge that is openly available to



multiple firms and individuals that seek to produce competing and complementary innovations, which have implications for the firms and individuals that consume those products. As a result, the integrative framework facilitates the organization and empirical research of this dissertation as follows.

Chapter 3 investigates open contribution, which specifically falls in quadrant 1, firm centric open innovation with the goal of developing new products for macro consumption. This chapter introduces concepts from the marketing capabilities literature (Morgan and Slotegraaf 2012) into the open innovation domain by explaining how specific adaptive marketing capabilities (Day 2011) are important mechanisms that firms leverage to create and commercialize innovations from the external knowledge that is gathered through open contribution. Methodologically, this essay develops an original scale to measure adaptive marketing capabilities and open contribution, and it gathers primary survey data to empirically test the hypotheses. Thus, this research identifies adaptive marketing capabilities as mediating mechanisms to explain how open contribution affects innovation outcomes.

Chapter 4 examines nonmarket innovation, which falls into quadrant 4, non-firm centric open innovation that creates new products for individual consumption. This chapter draws upon the emerging views of social production (Benkler 2006). The social production perspective offers insight to explain how individuals are able to innovate without oversight from any governing organization and without using traditional market transactions to produce and consume new products. Further, this essay advances the concept of community selection as a critical mechanism that enables this nonmarket form of innovation to be successful and grow rapidly in popularity. Empirically, this chapter relies upon a rigorous multi-method approach that

includes secondary data and behavioral lab data to test the hypotheses in the emerging nonmarket innovation context of 3D printing communities.

In summary, this literature review offers an integrative conceptual framework of open innovation to build a foundation for essays that provide theoretical explanations for differences and commonalities among numerous prevalent types of open innovation, and differences among firms, communities, and individuals that pursue open innovation to develop new products. Further, each area of this research identifies and advances specific mechanisms that enable the successful innovation outcomes from various approaches to open innovation. It is notable that these mechanisms have received limited discussion in the extant literature, which provides additional opportunities for this research to contribute to the marketing literature and innovation management literature.

Finally, this dissertation offers explanations for differences in innovation outcomes that are achieved through the use of different approaches to open innovation. Each chapter submits empirical tests of the mechanisms that enable the new product outcomes of open innovation. As a result, this dissertation provides opportunities to advance our theoretical and empirical understanding of how open innovation occurs and which mechanisms are needed to achieve desired innovation outcomes. Such contributions hold important managerial insight, which will be discussed at the conclusion of each of the following chapters.

## **Chapter 3**

### **A Dynamic Marketing Capabilities Perspective of Open Contribution during New Product Development**

#### **3.1 Introduction**

Endorsed by CEO Jeff Immelt, General Electric (GE) recently committed \$200 million to its ecomagination open innovation program. The ecomagination program was created with the directive of developing and commercializing innovative clean technologies through the solicitation of innovative ideas from external stakeholders. Also, GE Healthcare created an open business model with the specific purpose of innovating with a network of small business customers. Its small outpatient imaging centers are one of GE's fastest growing customer segments that now generate 40% of GE's diagnostic imaging business. The open innovation initiative has leveraged external knowledge resources to improve customer loyalty, create less competitive buying situations for GE Healthcare's products, and strengthen GE's financial position (Venkatram and Gouillart 2010b).

Within the domain of open innovation, *open contribution* describes an inbound knowledge approach in which external stakeholders actively provide their input to a firm's new product development (NPD) process (O'Hern and Rindfleisch 2010). Open contribution emphasizes the acquisition of external knowledge through a firm's efforts to identify and gather novel ideas during NPD (Gassmann and Enkel 2004). This collaborative perspective typically emphasizes cooperation with external stakeholders and developing multiple channels to absorb external knowledge in order to accumulate learning and innovation (Belussi, Sammarra, and Sedita 2010). GE's open innovation efforts are an exemplar of the inbound, knowledge-based

conceptualization of open contribution in which external knowledge is exploited by a focal firm (Bianchi et al. 2011; Enkel, Gassmann, and Chesbrough 2009; Gassmann and Enkel 2004).

This conceptualization of open contribution relies heavily upon the knowledge management aspects of open innovation (West, Vanhaverbeke, and Chesbrough 2006). While this inbound knowledge perspective helps delineate a popular form of open innovation, it does not explain how open contribution helps firms to leverage resources that they do not possess. Our understanding of the mechanisms that enable the benefits of open contribution is limited because existing views of open contribution tend to be static, as researchers typically focus on available knowledge stocks at one point in time. The tendency to conceptualize open contribution in terms of the tactical exploitation of knowledge resources follows its resource-based view foundation, which advocates exploiting existing resources and core competencies (Leonard-Barton 1992; Wernerfelt 1984).

However, firms create competitive advantage by choosing appropriate knowledge flows for the purpose of accumulating knowledge stocks (Dierickx and Cool 1989). To leverage knowledge flows, firms must develop and effectively utilize the capabilities that they possess in order to achieve competitiveness in the marketplace. Due to the tendency of open contribution discussions to focus on knowledge stocks, little is known about how to implement an open contribution paradigm or how firms interpret and convert external knowledge to create innovations. Missing from the discussion are organizational capabilities and the how the dynamic, boundary-spanning expertise of marketing can leverage the information and knowledge flows that are gained through open contribution.

Previous research suggests that a firm's dynamic capabilities, which are defined as "the capacity to create, extend, and modify the firm's operational capabilities" (Helfat et al. 2009;

Helfat and Winter 2011), are critical to creating and maintaining a firm's competitive advantage. The dynamic capabilities literature asserts that firm capabilities include specific organizational processes that acquire and combine resources to create new value and develop sources of competitive advantage (Eisenhardt and Martin 2000). Dynamic capabilities include both knowledge creation and transfer mechanisms (see Eisenhardt and Martin 2000 for a detailed discussion). Such capabilities are particularly important for integrating and utilizing external knowledge that may be accessible to competitors. A firm that pursues open contribution must develop capabilities to identify and value external knowledge, integrate it with existing internal knowledge, and convert it into new products (Huston and Sakkab 2006).

One such group of emerging capabilities is termed adaptive marketing capabilities. Adaptive marketing capabilities are mechanisms that facilitate the firm's learning process for acquiring, interpreting, integrating, codifying, and transforming external knowledge into commercializable and non-commercializable outcomes (Day 2011). These capabilities seek to explore new knowledge and other resources that lie outside the boundaries of the firm, and to discover new ideas through experimentation (Day 2011; March 1991). Adaptive marketing capabilities emphasize actively searching the market and continuously trialing new product ideas to anticipate market changes rather than simply monitoring the environment and passively absorbing information (Morgan 2012). Adaptive marketing capabilities enable the firm to make sense of the noisy market information in order to match relevant external knowledge with internal knowledge of customers and markets. The firm must leverage adaptive marketing capabilities to convert raw knowledge stocks into innovations that satisfy latent customer needs, commercialize the innovation through the launch of new products, or license and/or sell the resulting intellectual property. Consequently, adaptive marketing capabilities emphasize a

dynamic, higher level of involvement with external stakeholders, from idea generation through value creation and appropriation (Day 2011).

While adaptive marketing capabilities are built upon a solid foundation of marketing capabilities, they extend the reach of marketing capabilities by adding more dynamic dimensions that enable the firm to anticipate market changes, continuously test new ideas in the market to obtain insightful feedback, and rapidly respond with innovative products that meet latent customer needs. For example, the original formulation of marketing capabilities tends to accentuate the static nature of exploiting internal firm assets (Day 1994). Although the market-driven approach to marketing capabilities (Day 1994) emphasizes the exploitative use of existing knowledge and assets, the adaptive view of marketing capabilities (Day 2011) emphasizes an outside-in, exploratory aspect of the market learning process and open interaction with network stakeholders during the innovation process. Adaptive marketing capabilities build upon our understanding of marketing capabilities because they offer a more proactive, forward-looking approach to gathering and leveraging external knowledge flows.

As a result, the traditional view of marketing capabilities is improved by incorporating the dynamic elements of adaptive marketing capabilities in order to explain open contribution. For example, firms do not simply need stronger market sensing capabilities in order to gather greater volumes of external knowledge to achieve financial performance (Morgan, Slotegraaf, and Vorhies 2009). Rather, organizations that utilize open contribution need an emphasis on anticipating market changes and future customer needs (Day and Schoemaker 2008). Another relevant example is product development capability, which is conceptualized as an intermediate, organizational-level marketing capability (Morgan and Slotegraaf 2012). Such notions of product development are inclined to be static and focus on exploiting internal R&D knowledge in

familiar markets rather than utilizing external knowledge and reaching new markets through unexplored channels (Day 2011; Vorhies and Morgan 2005). Accordingly, the traditional conceptualization of marketing capabilities can be expanded to bolster our understanding of the phenomena of exploring external knowledge through open contribution

Although there is anecdotal evidence suggesting that the use of open contribution is expected to intensify in the future, there is a lack of systematic evidence that explains and predicts the underlying mechanisms that enable the process of sourcing, screening, evaluating, acquiring, and leveraging external knowledge for a firm's NPD process (Dahlander and Gann 2010; Enkel, Gassmann, and Chesbrough 2009). Open contribution continues to gain importance in practice, yet some skeptics view it as a short-term means to exploit knowledge spillovers while questioning its potential to create long-term value (West, Vanhaverbeke, and Chesbrough 2006). This hesitation is understandable given that the extant knowledge-based literature ignores the dynamic, process-oriented aspects of how open contribution occurs. Consequently, firms remain uninformed as to how open contribution should be implemented to achieve desired performance outcomes.

As a result, this research is of timely importance because implementation of open contribution is ultimately within marketing's domain. This chapter seeks to introduce the adaptive marketing capabilities framework in the open innovation literature by explaining how adaptive marketing capabilities are important mechanisms that firms leverage to create and commercialize innovations from the external knowledge that is gathered through open contribution. This paper seeks to answer calls for research to extend the marketing capabilities literature by linking marketing capabilities to open innovation, external knowledge utilization, and firm performance outcomes (Morgan and Slotegraaf 2012). Examining the effects of open

contribution and marketing capabilities on performance expands theory, provide guidance for future research in both areas of inquiry, and offer practical guidance on which capabilities are needed to achieve desired performance outcomes. Thus, my specific research questions are:

- What are the innovation outcomes of open contribution?
- What are the innovation outcomes of adaptive marketing capabilities?
- How do adaptive marketing capabilities mediate open contribution's effects on innovation outcomes?

The remainder of this chapter is organized as follows. Section 2 provides the conceptual framework for open contribution and the integral role of adaptive marketing capabilities. Hypotheses are developed that consider the effects of open contribution and adaptive marketing capabilities on innovation outcomes and the mediating role of adaptive marketing capabilities. Then, section 3 describes the methodology, operationalization of variables, and data collection for empirically testing the hypotheses. Next, section 4 reports the data analysis and results of the empirical tests, which suggest the mediation of adaptive market experimentation capability and open marketing capability between open contribution and innovation outcomes. Finally, section 5 concludes the chapter by offering theoretical contributions, managerial implications, limitations, and future research opportunities.

### **3.2 Conceptual Framework and Hypotheses**

This section explains how open contribution affects innovation outcomes through the mediation of adaptive marketing capabilities. This research reveals that adaptive marketing



capabilities are necessary for the firm to evaluate external knowledge, interpret findings, extract deep insights, and generate innovations.

### **3.2.1 Open Contribution's Effect on Innovation Outcomes**

The term “open contribution” originates from the open source software movement. At the project level, open contribution encourages individuals that collaborate on software projects to have a “stated ethos” to allow volunteers to develop source code without constraints of any formal hierarchy (Crowston et al. 2005). The fundamental concept of open contribution reflects this unrestrictive spirit by attempting to make it easy for individuals outside of the focal organization to provide content and ideas without obtaining special development tools or permission from a centralized governing organization (Lundell, Persson, and Lings 2007). At its roots, this philosophy advocates giving up control of the process of content generation and over the individual developers who write software code for the project (Crowston et al. 2005).

From a firm-level perspective, open contribution describes the phenomena of organizations searching for external knowledge and involving external stakeholders in NPD. Open contribution is a one-way process in which the firm receives information from the environment for input into its NPD process. From this perspective, firms search for outsiders to provide ideas for the firm to commercialize (Boudreau and Lakhani 2009; Laursen and Salter 2006). Search activities strive to reach external knowledge by scanning the environment for existing ideas and technologies during NPD (Katila and Ahuja 2002).

Open contribution is distinct from other forms of open innovation in that the firm still utilizes internal mechanisms to retain control over choosing the external content to be used in the development of a new product (O'Hern and Rindfleisch 2010). For example, Procter & Gamble

(P&G) recognizes that the solutions to most of its customer needs lie outside of its organization, so it maintains a permeable boundary between its internal NPD efforts and its external contributors (Dodgson, Gann, and Salter 2006). P&G solicits contributions from its knowledge network, which includes consumers, suppliers, universities, retailers, competitors, and other stakeholders (Huston and Sakkab 2006). However, P&G retains control over the selection process, since its internal employees evaluate external ideas on the basis of market potential and technical feasibility. Similarly, other NPD activities, such as development, testing, and commercialization, might still be led internally or completely controlled by the organization. This is because, as some authors suggest, to operate successfully in an open environment, the focal firm benefits from retaining control of the intellectual property solutions (Alexy, Criscuolo, and Salter 2009).

Since external knowledge is increasingly abundant (Chesbrough 2003), open contribution seeks this knowledge through the involvement of diverse external stakeholder perspectives in the innovation process. Higher diversity of open contribution indicates an increased number and wider range of different types of external sources of knowledge (Belussi, Sammarra, and Sedita 2010; Laursen and Salter 2006; Leiponen and Helfat 2010). As such, external contributors can include customers, suppliers, competitors, consultants, universities, and other innovation network entities (Laursen and Salter 2006). Open contribution paradigms suggest that external contributions from diverse stakeholders should be permitted throughout the NPD process (Chesbrough 2006). A firm that uses a high number of diverse knowledge resources is able to widely scan its environment to find new external knowledge for its NPD process (Laursen and Salter 2006). Thus, open contribution holds a predisposition to extensively search for and acquire external sources of knowledge (Acha 2007).

As a complex paradigm that continues to evolve, open contribution's effect on new product outcomes remains mixed. For instance, when developing and commercializing new products, firms often seek ideas that can be brought to market quickly. Speed to market is an important determinant of new product success because it enables an organization to capture profits before the entry of substitute products by competitors (Bayus 1997). Yet open contribution, through the diversity of external stakeholder involvement and the degree of external knowledge accessed, may slow down product development speed due to the volume and complexity of the knowledge processed. High levels of diversity can lead to difficulty in resolving conflicts given numerous perspectives, thus preventing the intended positive benefits of diversity (Ancona and Caldwell 1992; Olson, Walker and Ruekert 1995). As a result, when searching for external knowledge, firms sometimes suffer information overload, which results in inefficient decision-making that delays the NPD process (Day 2011).

Conversely, there are several benefits to NPD from open contribution. In particular, external knowledge search and diversity of stakeholder involvement are believed to positively impact novelty. Firms with a more open search for external knowledge tend to be more innovative (Laursen and Salter 2006) because they are able to absorb external ideas to leverage the creativity and discoveries of others (Dahlander and Gann 2010). According to Cohen and Levinthal (1990), a wide range of stakeholders and knowledge sources enables a firm to enhance the novelty of innovations because the diversity of external knowledge sources activates novel linkages. Firms that utilize open contribution are able to gather ideas from numerous, diverse sources instead of only relying on internal R&D (Laursen and Salter 2006). While internal employees may hold preconceived biases that limit their range of ideas for new products, diverse sources of external knowledge lead to more creative ideas that challenge alternative ways of

thinking within the organization (Burt 2004). Diverse perspectives offer different approaches for solving latent, unmet customer needs, leading to more novel product ideas (Bindroo, Mariadoss, and Pillai 2012). Novelty is particularly important because the absence of innovativeness is a primary determinant of new product failure (Sethi, Smith, and Park 2001). By searching for external sources of new ideas, firms that practice open contribution are able to incorporate more novel ideas, leading to improved innovation outcomes (Laursen and Salter 2006; Leiponen and Helfat 2010).

In addition to positively impacting the novelty of new products, open contribution may also benefit patenting and licensing activities. While the usual goal of organizations is to commercialize innovations directly through existing channels and markets, open innovation paradigms also advocate expanding the market for non-commercialized ideas through patenting and external licensing (Chesbrough 2006). Open contribution affects organizations' patenting activity because diversity of external knowledge search causes an increase in numerical patent output (Belussi, Sammarra, and Sedita 2010). Accessing diverse knowledge sources gives organizations an opportunity to find more unique ideas that may be patentable. Furthermore, open contribution leads to an increase in licensing opportunities. Through the process of seeking external feedback for new product ideas, the organization can discover alternative markets that might be interested in the new product idea, even if it is not economically or technically feasible for the firm to directly develop and commercialize the idea through its existing channels. This open dialogue with external network stakeholders may present opportunities to license ideas through the organization's extended innovation network. As such, this study hypothesizes:

H<sub>1a</sub>: The degree of diversity of external stakeholder involvement during NPD negatively impacts new product i) speed to market, but positively affects new product ii) novelty, iii) patents and iv) licensing.

H<sub>1b</sub>: The degree of external knowledge search during NPD negatively impacts new product i) speed to market, but positively affects new product ii) novelty, iii) patents and iv) licensing.

Although open contribution has important consequences for innovation outcomes, it is insufficient to focus exclusively on the beginning of the NPD process when ideas are generated and the end of the NPD process when innovations are commercialized, patented, or licensed. Rather, the uncertainty surrounding how open contribution occurs demands a closer look at understanding how external knowledge is gathered, codified, and converted into innovations. The next section discusses how external knowledge that is gathered through open contribution is effectively processed by firms' adaptive marketing capabilities.

### **3.2.2 Open Contribution and Adaptive Marketing Capabilities**

The focus of most research on open innovation has been on the absorption of external knowledge (Chesbrough 2003a). The permeable boundaries of the open firm's NPD process facilitate the active exchange of knowledge between a firm and its environment with the purpose of creating new products to satisfy customers. Since open contribution accentuates harnessing external knowledge sources, a greater emphasis on open contribution can be expected to be associated with the acquisition of more external knowledge.

It naturally follows that the existing R&D knowledge possessed by the firm provides a base level of complementary knowledge to aid the absorption of external knowledge (Cohen and Levinthal 1989). This complementary knowledge helps the firm to comprehend external knowledge and how it fits with the existing technical knowledge that is possessed by the firm (Yao, Yang, Fisher, Ma, and Fang 2013). Yet while the nature of absorptive capacity is typically concerned with internal R&D knowledge stocks, a focus on absorbing external knowledge does not fully unpack the underlying processes of open contribution in order to inform theory and practice.

In other words, open contribution cannot be explained through the idea that simply absorbing more external knowledge will enable the firm to succeed. If external knowledge is available to numerous firms, then a lingering question is why some firms fail to reap the benefits of available external knowledge, which other firms do not pursue open contribution at all. More knowledge certainly has the potential to help the NPD process, but knowledge accumulation alone is an insufficient condition for innovation to occur. An attempt to receive highly diverse external knowledge can lead to information overload that overwhelms a firm's capability to use the knowledge during NPD (Ritter and Walter 2012). Moreover, firms do not possess equal capabilities to absorb, integrate, and convert external knowledge into marketable new products (Cohen and Levinthal 1990; Day 2011).

To achieve successful new product outcomes, open contribution requires firms to cultivate different, yet complementary, marketing capabilities to sense knowledge that matches market opportunities, interact and transfer knowledge with external stakeholders, and create value for customers through the commercialization of new products. As indicated by recent research, a deficiency of marketing knowledge is a major obstacle that causes firms to decide to

keep their NPD processes relatively closed rather than pursuing open innovation (Drechsler and Natter 2012). Thus, the key to open contribution is not the acquisition of external knowledge. The critical piece of open contribution is how the knowledge is effectively evaluated, selected, and commercialized to meet market needs.

Firms accomplish the process of matching customer information to innovation knowledge to commercialize new products through their marketing capabilities. Marketing capabilities enable firms to sense latent customer needs and to respond to the market intelligence that they gather by creating new value to meet those needs (Day 1994, 1999; Morgan, Vorhies, and Mason 2009). Although absorptive capacity provides a foundation to acquire external knowledge, marketing capabilities are more closely linked to the commercialization and value appropriation aspects of innovation. In other words, marketing capabilities enable firms to process market information in order to “define, develop, and deliver value to their customers by combining, transforming, and deploying their resources in ways that meet market needs” (Morgan and Slotegraaf 2012). Such marketing capabilities help firms to integrate external knowledge with internal expertise in customer preferences. Thus, while searching for and accumulating external knowledge supports the value creation aspect of innovation, marketing capabilities aid the firm in appropriating the value generated through the transformation of the external knowledge.

In particular, adaptive marketing capabilities are linked to open contribution because adaptive marketing capabilities build their foundation upon an outside-in approach to NPD (Day 2011). As explicated above, open contribution is an innovation paradigm that advocates a willingness to consider diverse perspectives, receive divergent information, and explore new ideas generated by an extended network of customers, suppliers, and other network partners (Day 2011; O’Hern and Rindfleisch 2010). Adaptive marketing capabilities augment the

traditional view of marketing capabilities by providing specific, dynamic mechanisms to proactively search for external knowledge, to learn by iteratively involving diverse and flexible partner resources in new product activities, to gather and discern novel ideas, to develop new products through frequent experimentation with the market, and to commercialize innovations by mobilizing the capabilities of network partners (Day 2011). Adaptive marketing capabilities are comprised of three components that are described below: vigilant market learning, adaptive market experimentation, and open marketing.

*Vigilant Market Learning.* First, vigilant market learning is an organization's capability to proactively search for clues in its environment to sense changing customer needs and quickly respond to emerging patterns (Day 2011). This capability is rooted in an organization's practices of market sensing (Day 1994), market orientation (Jaworski and Kohli 1993; Kohli and Jaworski 1990; Slater and Narver 1995), and organizational learning (Moorman 1995).

Market orientation provides the firm with a willingness to react to information gathered from customers and market trends (Kohli and Jaworski 1990). However, vigilant market learning moves beyond market orientation in two areas. First, vigilant market learning focuses on market signals that lie in the periphery of the organization, with a particular emphasis on paying attention to information that is beyond the immediate feedback received from customers (Day 2011). These signals may come from other sources such as suppliers, competitors, and trends from industries in which the focal firm does not participate. Attentional vigilance emphasizes responsiveness to such environmental signals in order to make sense of the potentially overwhelming amount of external information that is available (Ocasio 2011). Second, vigilant market learning emphasizes anticipating market changes rather than reacting to existing



environmental conditions. While, market orientation enables the firm to detect market information and distribute it internally, organizational learning occurs when a firm's managers adjust their operational tactics and beliefs in response to processing information gathered from the market (Baker and Sinkula 1999). Thus, vigilant market learning exhibits an organization's dynamic ability to transform itself to take advantage of pending market changes.

The marketing capabilities literature describes market orientation and market sensing skills as prerequisites to learning from external information (Day 1994; Morgan 2012). However, vigilant market learning emphasizes a more proactive approach to market learning that anticipates market changes, before they are realized by competitors, rather than passively monitoring the environment (Day 2011; Morgan 2012). While open contribution focuses on accessing and leveraging external knowledge, it does not provide "free" resources because firms encounter challenges related to filtering, integrating, and learning, which obstruct their ability to utilize external knowledge. Vigilant organizations are able to filter the increasing amount of information available externally to see through the noise and find the relevant knowledge that is valuable for its markets. Such organizations can effectively evaluate large volumes of external information, interpret and acquire valuable knowledge, and select high potential ideas that other firms are unable to discern.

The dynamic, outside-in approach of vigilant market learning capability seeks to continuously gathering new ideas from customers and other important network actors (Day 2011). The vigilant market learning approach to NPD underscores the goal of uncovering latent market needs rather than reacting to the introduction of competitors' products. Vigilant organizations intensely scan their environment to discover market information that forewarns pending changes that may threaten the organization (Huber 1991; Sutcliffe 1994). These firms

maintain an active state of high alertness to sense weak market signals and interpret emerging opportunities and threats (Day and Schoemaker 2005). Thus, this study hypothesizes:

H<sub>2a</sub>: The degree of diversity of external stakeholder involvement during NPD is positively related to vigilant market learning capability.

H<sub>2b</sub>: The degree of external knowledge search during NPD is positively related to vigilant market learning capability.

*Adaptive Market Experimentation.* Second, adaptive market experimentation is the capability to continuously learn from trial-and-error interactions with external knowledge sources (Day 2011). Adaptive market experimentation capability places a strong emphasis on processing external knowledge. It includes a systematic effort to test new product ideas externally to obtain feedback and fosters a tolerant climate where it is possible to learn from failed products and ideas that are tested in the market (Day 2011). This willingness to challenge internally-held assumptions and tolerate trial-and-error learning during NPD allows the organization to achieve generative learning that dynamically links the changing environment to internal knowledge and processes (Slater and Narver 1995). During the NPD process, this continuous learning is achieved by methodically engaging a broad array of external knowledge sources to extract insights, codify knowledge, and share learning within the organization (Day 2011).

Thus, adaptive market experimentation is needed to link external ideas available through open contribution to the organization's NPD process. While vigilant market learning is focused on finding weak market signals that foreshadow changing customer needs, adaptive market experimentation concentrates on codifying and transforming knowledge to generate deep market

insights (Day 2011). Deep insights are produced through the generative learning process that links external knowledge with internal knowledge. As a dynamic capability, adaptive market experimentation helps the firm to “integrate, build, and reconfigure” (Teece, Pisano, and Shuen 1997) internal and external knowledge to develop new products that anticipate changing market preferences. The iterative process of obtaining feedback on new insights helps the firm to convert the knowledge into innovations.

Externally-focused firms have superior processes for interacting with the peripheral environment, acquiring external knowledge, and utilizing that knowledge to implement the firm’s strategies (Moorman 1995). In the context of open contribution, adaptive market experimentation enables the firm to codify external knowledge, generate deep marketing insights, and transform the raw external knowledge into innovations. As such, adaptive market experimentation is a higher-order, inter-organizational level capability (Morgan and Slotegraaf 2012) that enables the firm to learn from its environment, modify the external knowledge that is gathered, and reconfigure the new insight to develop innovations. Thus, this study hypothesizes:

H<sub>3a</sub>: The degree of diversity of external stakeholder involvement during NPD is positively related to adaptive market experimentation capability.

H<sub>3b</sub>: The degree of external knowledge search during NPD is positively related to adaptive market experimentation capability.

*Open Marketing.* Third, open marketing is the capability of leveraging deep marketing knowledge, which is held both within the organization and externally through network partners (Day 2011). A firm that practices open contribution during NPD benefits from sustaining numerous external relationships. The firm must be sufficiently knowledgeable about key external

knowledge sources to be able to coordinate innovation input and output across the innovation network (Dahlander and Gann 2010). Likewise, open marketing capability is founded upon extensive knowledge of marketing network partners such that the firm knows which stakeholders to involve in the commercialization of its innovations (Day 2011). Open marketing strives to enable the organization to mobilize dispersed partner resources with complementary skills and resources to leverage wider knowledge and capabilities, more varied contributions, and new insights (Day 2011). Thus, it is beneficial for firms to build and manage innovation networks of diverse partners to effectively leverage external knowledge. (Belussi, Sammarra, and Sedita 2010). This knowledge of markets and stakeholders enables the firm to leverage extended marketing capabilities by accessing the complementary skills of innovation network partners (Day 2011).

Although open marketing seeks to build upon accumulated internal marketing knowledge by accessing and leveraging the external resources that are complementary to the organization's knowledge (Day 2011), it is not equivalent to outbound open innovation. The outbound paradigm occurs when the firm departs from the typical internal commercialization process to transfer non-commercialized ideas to the external environment through nontraditional paths to market innovations (Chesbrough 2006; Enkel, Gassmann, and Chesbrough 2009). In contrast, open marketing requires “coordination, control, and sharing skills needed to act on the insights from their diverse partners while keeping the insights proprietary” (Day 2011). Thus, while open contribution permits information to flow into the organization's permeable boundaries, a firm's open marketing capability effectively monitors the inflow and outflow of knowledge to collaborate and share value with partners and simultaneously protect key intellectual property and its value for the firm. In the context of open contribution, open marketing enables the firm to

leverage the complementary skills of its innovation network to produce innovation outcomes.

Therefore, this study hypothesizes:

H<sub>4a</sub>: The degree of diversity of external stakeholder involvement during NPD is positively related to open marketing capability.

H<sub>4b</sub>: The degree of external knowledge search during NPD is positively related to open marketing capability.

Hence, adaptive marketing capabilities seek to discover, interpret, integrate, codify, transform, and utilize knowledge that is available externally via open contribution. Organizations engage their adaptive marketing capabilities to purposefully leverage the external knowledge to enhance their NPD processes and generate commercialized and non-commercialized innovation outcomes. The following section explicates the effect of adaptive marketing capabilities on specific innovation outcomes.

### **3.2.3 Adaptive Marketing Capabilities and Innovation Outcomes**

Adaptive marketing capabilities positively influence innovation outcomes. Vigilant market learning capability increases the novelty of the organization's new products by helping the firm to gather and share diverse knowledge within and across organizational boundaries (Day and Schoemaker 2008). Vigilant market learning includes a commitment to bringing together different perspectives to discover new insights rather than relying on internal biases (Day 2011). Vigilance aids such firms' learning from a broad pool of stakeholders including those in the periphery, not just major current customer bases (Day and Schoemaker 2005). Such organizations pay attention to the periphery because their extended network of partners

frequently has the ability to sense threats and opportunities that are not immediately obvious to internal employees that may have existing biases. This concern for the periphery aids firms in preventing organizational biases from inhibiting insights that are gathered from different stakeholder perspectives (Day 2011). As such, proactively seeking diverse external perspectives helps firms to discover more novel insights from existing knowledge that is available from multiple stakeholders (Day and Schoemaker 2008).

Vigilant market learning increases new products' speed to market. Vigilant organizations are able to sense emerging technologies and understand how the pending changes have the ability to disrupt current products and markets (Day and Schoemaker 2005). This proactive approach to market sensing enables firms to find valuable external knowledge sooner than competitors, which provides a potential opportunity to bring products to market faster. Vigilant market learning provides an "advance warning system" to discern trends and shifts in customer needs (Day 2011). This early warning provides an opportunity for organizations to adapt to pending changes rather than reacting to shifts that have already occurred. Vigilance emphasizes seeing through the fog to sense future market changes before they are fully apparent to competing organizations (Day and Schoemaker 2004). This emphasis on anticipation helps the firm to gather and share knowledge for its innovation process so that it can rapidly respond by filling unmet customer needs.

Additionally, vigilant market learning has a positive effect on non-commercialized innovation outputs such as patents and licensing. Proactive search for external knowledge helps the firm to discover innovative ideas that, when combined with deep internal knowledge, may become patentable. Further, as the firm explores novel external knowledge, it may encounter opportunities to externally license the innovations through new markets and new stakeholder

relationships that originated through vigilant market learning. Since vigilance emphasizes anticipating market needs, the firm may realize an adjacent, nontraditional market or channel that will value the innovation immediately if the firm's typical channels and customers are not ready to adopt the new idea. Therefore, this study hypothesizes:

H<sub>5a</sub>: Vigilant market learning capability has a positive effect on (i) speed to market, (ii) novelty, (iii) patents, and (iv) licensing.

Adaptive market experimentation capability has a positive effect on new product novelty because it emphasizes a systematic effort to incorporate ongoing contributions from a wide array of innovation network partners (Day 2011). The integration of diverse external perspectives aids the discovery of innovative ideas that are unfamiliar to existing employees that tend to lean on their path dependent, accumulated knowledge. Instead, adaptive market experimentation embraces a willingness to challenge existing internal beliefs (Day 2011). The ability to look outside the familiar, comfortable realm of existing product knowledge encourages employees to resist the urge to pursue the known, incremental ideas in favor of discovering more novel innovations that are beyond their prior experience.

Adaptive market experimentation provides firms with frequent, valuable stakeholder feedback on potential new product ideas. This trial-and-error approach to NPD is conducive to rapid learning and the discovery of innovations, leading to faster speed to market (Day 2011). Adaptive organizations value diverse, fragmented external knowledge, because they are able to quickly interpret the information and respond to market needs. The interpretation and decision-making aspects of adaptive market experimentation is conducive to accelerating new products to market. Gathering continuous feedback encourages the firm to quickly terminate ideas that are

unlikely to be successful while expediting the development and commercialization of products that are likely to be adopted by customers.

Since adaptive market experimentation enables the organization to quickly evaluate ideas for technical feasibility and market potential, ideas that are not immediately commercialized are able to be patented or licensed. Adaptive market experimentation helps firms to discern the value of external knowledge more quickly than competitors. Thus, adaptive firms have a greater opportunity to obtain patents or licensees for the ideas that are not pursued for internal development. Therefore, this study hypothesizes:

H<sub>5b</sub>: Adaptive market experimentation capability has a positive effect on (i) speed to market, (ii) novelty, (iii) patents, and (iv) licensing.

Finally, open marketing capability has a positive effect on new product novelty because it emphasizes orchestrating the capabilities and resources of network stakeholders during the commercialization of new products (Day 2011). If the firm develops a novel product that may not be readily adopted by existing customers, the firm can leverage the capabilities of its extended network to market the product during commercialization. The additional resources from the extended innovation network can help speed the product market when it otherwise may have been bogged down prior to launch.

Diverse innovation network partners are able to expedite the adoption of novel products by using their own marketing capabilities, which extends the reach of the focal firm. In the absence of open marketing capability, incorporating external knowledge might bring in the undesirable habits of other firms. However, open marketing capability contains important dimensions that help the organization to monitor and coordinate the flow of information in and



out of the organization. This coordination skill helps the firm to avoid information overload and enables it to efficiently speed products to market (Day 2011).

Further, open marketing makes available a richer array of resources and capabilities than are found in a closed innovation model (Day 2011). By leveraging a more talented pool of inter-organizational resources and capabilities, organizations can find multiple outlets to profit from innovations (Dyer and Singh 1998). Such outlets include the nontraditional paths to market of patents and external licensing that are advocated by open innovation paradigms (Chesbrough 2006). Therefore, this study hypothesizes:

H<sub>5c</sub>: Open marketing capability has a positive effect on (i) speed to market, (ii) novelty, (iii) patents, and (iv) licensing.

As such, adaptive marketing capabilities allow the firm to iteratively leverage the extended capabilities and resources of innovation network partners. To that end, the next section submits that adaptive marketing capabilities are mediators that enable the positive effects from open contribution on innovation outcomes.

### **3.2.4 Adaptive Marketing Capabilities Mediate the Effect of Open Contribution on Innovation Outcomes**

Independently, open contribution is positively associated with adaptive marketing capabilities, and open contribution and adaptive marketing capabilities have positive effects on innovation outcomes. Yet although seeking knowledge from diverse external sources explores new ideas, acting on those ideas requires additional skills. The generation and collection of novel ideas from dispersed external knowledge sources has little correlation with innovation

implementation success (Burt 2004). Prior research has indicated that involving dispersed stakeholders in a firm's innovation process leads to coordination difficulty due to the unique perspectives and languages of the sources of knowledge, a problem that is compounded with novel ideas that are unfamiliar to the organization (Obstfeld 2005).

As such, adaptive marketing capabilities are revealed to be a critical mechanism that enables open contribution to benefit new product outcomes. This mechanism is valuable because, with open contribution alone, firms may search their environment for knowledge but not utilize the knowledge to create innovative products. Searching for and accumulating external knowledge is insufficient to achieve innovation outcomes. Such firms may lack internal mechanisms for being able to interpret and convert the knowledge into new products. For example, a focus of P&G's open contribution effort is to systematically search for ideas externally, and then improve upon and convert those ideas utilizing internal capabilities (Huston and Sakkab 2006).

In particular, adaptive marketing capabilities describe vigilant market learning as a necessary capability for organizations to utilize external knowledge. A critical aspect of vigilant market learning is accurate interpretation, valuation, and decision-making on whether to develop or discard external knowledge. The vigilant firm knows how to ask the right questions to be able to accurately evaluate the market potential of external knowledge for feasible innovation solutions. Vigilant market learning enables the use of external knowledge because learning from the environment is not fully realized until the organization accurately interprets and shares the acquired knowledge (Day 2011). Thus, this study hypothesizes:

H<sub>6a</sub>: Vigilant market learning positively mediates the relationship between diversity of external stakeholder involvement, external knowledge search, and the innovation outcomes of (i) speed to market, (ii) novelty, (iii) patents, and (iv) licensing.

Second, firms use adaptive market experimentation to internally codify external knowledge, generate new knowledge, and share deep market insights across their innovation processes (Day 2011). Such firms use adaptive market experimentation to generate unique market insights from the combination of external and internal knowledge, codify those insights for the organization's use, and to continuously test product ideas externally. This adaptive process is necessary in order to internalize external knowledge and create innovations. Thus, this study hypothesizes:

H<sub>6b</sub>: Adaptive market experimentation positively mediates the relationship between diverse external stakeholder involvement, external knowledge search, and the innovation outcomes of (i) speed to market, (ii) novelty, (iii) patents, and (iv) licensing.

Third, firms use open marketing capability to leverage diverse external partner involvement during the commercialization stage of NPD. A key element of open marketing is the ability to utilize insights gained from diverse partner contributions yet keep the insights proprietary. This requires effectively monitoring the flow of information in and out of the firm while sharing value with the organization's external innovation network (Day 2011). Thus, adaptive marketing capabilities are internal capabilities that enable the use and protection of external knowledge flows that are gathered through open contribution. Therefore, this study hypothesizes:

H<sub>6c</sub>: Open market capability positively mediates the relationship between diversity of external stakeholder involvement, external knowledge search, and the innovation outcomes of (i) speed to market, (ii) novelty, (iii) patents, and (iv) licensing.

In summary, this conceptual framework submits that the adaptive marketing capabilities of vigilant market learning, adaptive market experimentation, and open marketing each work independently to mediate the effects of open contribution on the resulting innovation outcomes. The next section describes the methodological approach to collect appropriate data for the research, operationalize the variables, and empirically test each hypothesis.

### **3.3 Method**

#### **3.3.1 Data Collection**

The research progressed in two stages. In stage one, I conducted ten in-depth interviews with executives who are actively engaged in their firms' product development and marketing of innovations. Due to the emerging nature of open contribution and adaptive marketing capabilities, a discovery-oriented, inductive approach was employed to reveal and understand the key dimensions in this domain (Eisenhardt 1989; Menon et al. 1999). The qualitative interviews were completed with firms that practice varying degrees of open contribution as well as firms that utilize closed innovation approaches in order to better understand the differences between these paradigms and the mechanisms that they employ.

In stage two, based upon the key constructs identified during the interviews, a review of the related literature was conducted to generate a list of potential items to measure the constructs. In accordance with the process of developing constructs as suggested by Churchill (1979), the

literature review and interviews serve to specify the construct domain of open contribution and adaptive marketing capabilities. Due to the emerging nature of the practice of open contribution and because this study is among the first to operationalize adaptive marketing capabilities, many of the items were developed specifically for this study. As a result of this approach, the dimensions of open contribution and adaptive marketing capabilities are grounded in both the literature and business practice to ensure their theoretical and managerial relevance. The final items that are used for primary survey data collection to support this chapter are displayed in the Appendix.

To refine and validate the measurement scale, empirical data were collected through a survey questionnaire of managers and executives who are engaged in NPD at various firms that practice open innovation as well as firms that utilize a closed innovation approach. The commercial mailing list contained contact information for 1,930 people who specifically work in and/or have responsibility for NPD at their firms. The quantitative measurement questions are based on a seven-point Likert scale. A seven-point Likert scale is chosen because the optimal number of responses for typical reliability measures has been calculated to be seven (Cox 1980).

The initial survey respondents were asked to suggest additional potential respondents to be included in the sample in accordance with the snowball sampling method. This approach, also called referral sampling, yields better results at lower costs by reducing the search required to identify a sufficient number of qualified respondents (Hair et al. 2008). Moreover, the sample population was not restricted to a particular industry because using a random sample from multiple industries permits greater generalizability of the findings. Also, the inclusion of both open and closed firms allows for an unbiased comparison of open contribution and adaptive marketing capability processes as well as the resulting innovation outcomes. The survey was

pilot tested with a sample of 300 randomly selected managers and executives from the previously identified sample pool (Hair et al. 2008). The respondents noted no ambiguity or difficulty in completing the questionnaire.

After the items were evaluated and refined, the questionnaire was sent to the remaining 1,630 managers and executives from the sampling frame who were not contacted for the pilot test. Using this separate group for the actual data collection minimizes threats to internal validity that could occur if the same respondents were used over a period of time. An internet survey approach was used in order to minimize sources of error that could be caused by administration-related factors based on the setting or potential interviewer involvement (Viswanathan 2005). This method allows for unbiased, non-intrusive data collection.

The data collection yielded 228 responses that attempted the survey, which is a reasonable response rate of 14.0% compared to other recent surveys (i.e., von Hippel, de Jong, and Flowers 2012). Of those participants, 25 did not finish the survey, leaving 203 usable responses in the sample. To check for nonresponse bias (Armstrong and Overton 1977), early and late responses were compared in the following manner. The data collection occurred in two waves, with 118 individuals responding to the initial email solicitation to participate in the survey. After two weeks, a reminder email was sent to the remaining contacts in the sample frame, of which 110 individuals responded. There were two clear groups of respondents based upon the timing of the initial survey invitation and subsequent reminder email. Each item in the survey was averaged by group and compared with *t*-tests to find that there is no indication of response bias among the early group and late group of participants.

Respondents indicated job titles such as Vice President of Development and Innovation, Marketing Director, Marketing Manager, Product Manager, R&D Manager, Engineering

Manager, Innovation Manager, and New Product Development Manager. The survey instrument included a post hoc check for respondents to self-rate their knowledge of their firms' innovation processes. The median response is 7.00, and the mean response is 6.05 on a seven-point scale, indicating a high level of informant knowledge.

### **3.3.2 Measurements**

*Open Contribution.* Open contribution is operationalized with two constructs, external knowledge search and diverse external stakeholder involvement, which the qualitative interviews revealed to be key aspects of open contribution. Further, prior research indicates that these two constructs are important indicators of open contribution during NPD (Chesbrough 2006; Laursen and Salter 2006; Leiponen and Helfat 2010; O'Hern and Rindfleisch 2010). External knowledge search is measured with items that reflect innovation search that is external to the organization and external to the industry. Diverse external stakeholder involvement is measured with items that reflect the extent of external stakeholder involvement during the five stages of NPD, and the extent of participation by specific entities that include customers, suppliers, competitors, and other external stakeholders.

An additional construct, access to external knowledge, is utilized as an antecedent to external knowledge search and diverse external stakeholder involvement. The importance of access to external knowledge echoes Chesbrough's (2006) assertions that external knowledge is abundant and widely available. Moreover, other researchers have suggested that a firm's degree of access to external knowledge influences the organization's intensity and type of external search activities during NPD (Laursen and Salter 2006; Levinthal and March 1993).

*Adaptive Marketing Capabilities.* Adaptive marketing capabilities are measured with the three constructs of vigilant market learning, adaptive market experimentation, and open marketing. Vigilant market learning capability is measured with nine items that relate to how firms evaluate the market potential, evaluate the technical feasibility, select, and decide how to proceed with ideas generated from external knowledge. These items focus on action from market learning because of vigilant market learning's emphasis on sensing weak market signals, interpreting external data, and garnering proactivity (Day 2011).

Adaptive market experimentation capability is measured with five items that capture an organization's ability to generate deep insights from external knowledge and link those insights to the organization's NPD process. The organization uses adaptive market experimentation to extract insights and codify knowledge (Day 2011). The focus of these items is on taking action to convert the external knowledge that is revealed through open contribution into innovations.

Open marketing capability is measured with three items that relate to how the firm monitors and shares information and innovation value with its innovation network partners. A key aspect of open marketing is to coordinate, control, and monitor the information that is shared with innovation network stakeholders while protecting critical insights (Day 2011). In addition, market knowledge is measured with five items adapted from Day (1999) as key components of open marketing because deep market knowledge provides the foundation for the firm to build effective innovation network relationships and understand how to orchestrate its network's marketing resources (Day 2011).

*Innovation Outcomes.* Innovation outcomes are reflected by two product measures and two knowledge measures. The two new product measures are novelty and speed to market.



Novelty is defined as the extent that new products that originate from external knowledge are different from new products that are developed from the organization's internal ideas (Sethi, Smith, and Park 2001; Fang 2008). Speed to market, which is sometimes referred to as product development cycle time, is defined as the time elapsed from the conceptualization of the product idea through its launch into the marketplace (Fang2008; Griffin 1997). Like novelty, speed to market is a relative measure that asks respondents to rate how quickly their organizations develop innovations from external knowledge compared to the typical speed of development of innovations that originate from internal ideas.

The two knowledge output measures are patent and licensing activities. These measures ask the respondents to rate their organizations' propensity to capture external knowledge through non-commercialized new products. While these two measures are not typically used in the innovation management literature, they are included in this study because of open innovation's emphasis on accelerating the development of knowledge using nontraditional paths, including external paths such as selling patents or external licensing (Chesbrough 2006). As such, the two knowledge measures capture the creation of new knowledge that is not immediately commercialized as new products but still holds current or future value for the organization.

*Control Variables.* Three control variables are incorporated in the models to account for differences in firm characteristics. Firm age is included because younger firms may have less well-defined adaptive marketing capabilities, and they may lack established relationships from which to draw external knowledge. The natural logarithm of the approximate number of employees at the respondent firm is included in order to accommodate differences in firm size. Larger firms may have more resources to allocate to development of innovations, more dedicated

processes for external knowledge search, more external relationships to supply external knowledge, and more developed adaptive marketing capabilities for utilizing that knowledge. Further, firm size is often included as a control variable because it accounts for some differences in firm characteristics that affect performance outcomes (Leiponen and Helfat 2010).

Finally, the natural logarithm of the approximate annual R&D budget of the respondent firm is included as a control variable because firms with more R&D resources may exhibit a greater commitment to exploration of innovative ideas. This emphasis on R&D may increase the likelihood of developing innovative products and the revenues that ensue (Leiponen and Helfat 2010). Further, R&D resources may reflect a superior ability to identify, value, assimilate, and convert external knowledge. The three control variables are included as reflective items for one construct, “control variables,” because the coefficients behave consistently across the models. In other words, the three measures move together and are not expected to act differently when predicting their effect on innovation outcomes.

### **3.3.3 Measure Validation Procedure**

Initially, an exploratory factor analysis was conducted as a data reduction technique using principal components analysis and Varimax rotation (Iacobucci 2001). The results indicate an eight factor solution. All retained factors are meaningful and interpretable, and they have eigenvalues greater than one (Aaker 1997) Further, all of the retained factors have loadings higher than the conservative recommended cutoff of 0.400 (Iacobucci 2001). Table 1 reports the construct correlation matrix.

The models are estimated and interpreted in two stages. First, the reliability and validity of the measurement model are assessed. Second, the structural model is tested (Sarkar,

Echambadi, and Harrison 2001). Both stages of analysis are completed with Partial Least Squares (PLS) using SmartPLS 2.0 (Ringle, Wende, and Will 2005). PLS is appropriate for this study due to the exploratory nature of the research question, the lack of theory to explain open contribution, and the emerging conceptual view of adaptive marketing capabilities. Accordingly, PLS is often used for theory development in contexts of exploratory research such as the research in this study (Echambadi, Campbell, and Agarwal 2006; Ernst, Hoyer, and Rubsaamen 2010). Moreover, a goal of this research is to maximize the explained variance of the manifest variables while making minimal assumptions about the distribution of the data (Chin 2010; Hair et al. 2012).

The measurement model (i.e. the outer model) is evaluated by examining the individual indicator reliabilities. All constructs in the measurement model use reflective indicators because each item may capture a different but related aspect of the latent constructs (Chin 2010; Viswanathan 2005). Table 1 displays the Cronbach's alpha and composite reliability values of internal consistency reliability, which are important calculations to report for reflective measures (Echambadi, Campbell, and Agarwal 2006). The Cronbach's alpha statistics range from 0.780 to 0.951. The Cronbach's alpha values provide a lower bound estimate of reliability because Cronbach's alpha assumes that all indicators are equally weighted (the assumption of tau equivalency) (Chin 2010; Hair et al. 2012). Additionally, the composite reliability values range from 0.895 to 0.970. The composite reliability values provide a closer approximation of internal consistency that is more suitable when using PLS because composite reliability does not assume tau equivalency (Chin 2010; Hair et al. 2012). The internal consistency measures are all greater than 0.700, which suggests high levels of reliability and that the items adequately capture the latent constructs (Echambadi, Campbell, and Agarwal 2006).

Next, numerous checks for validity are conducted in accordance with the recommendations of Churchill (1979). First, satisfactory content validity is confirmed by relying on the qualitative interviews that were conducted prior to survey data collection. It is especially important to obtain the input of knowledgeable industry experts for an emerging topic such as open contribution because the meaning of open contribution continues to evolve practice. Second, having found high internal consistency with the reliability estimates reported in Table 1, the analysis focused on convergent validity and discriminant validity as a key step in evaluating construct validity. The average variance extracted (AVE) values are examined to assess convergent validity (Hair et al. 2012). Table 1 displays the AVE statistics, which range from 0.461 to 0.936. With the exception of diverse external stakeholder involvement (AVE = 0.461), all of the constructs far surpass the ideal value of 0.500, indicating that the rest of the constructs exhibit satisfactory convergent validity (Chin 2010; Fornell and Larcker 1981).

To assess discriminant validity, the procedure recommended by Chin (2010) was followed to compare the measurement model loadings and cross loadings. All items have stronger loadings for their respective constructs than for any other constructs measured, and items have stronger loadings than their cross loadings. This criterion provides sufficient indication of discriminant validity (Hair et al. 2012). Most other threats to validity will be avoided since there are no experimental treatments in this study and all of the survey respondents were provided the same questionnaire. Further, a random sample was purposefully taken from multiple industries to further improve the external validity of the findings. Taken together, all of these checks for validity provide increasing amounts of evidence in support of construct validity (Viswanathan 2005).

### 3.4 Results

After establishing confidence in the measurement model, the structural models (i.e. inner models) are estimated with PLS. A bootstrapping method of sampling with replacement was used to calculate PLS estimates on the basis of 250 resamples, which is a sufficient number to obtain reasonable standard error estimates and associated t-tests (Tenenhaus et al. 2005). Tables 1 through 5 include a summary of the results, which are discussed below.

#### 3.4.1 Direct Effects Models

First, the direct effects of open contribution on innovation outcomes are examined. This step establishes an initial model that reflects the external knowledge search and diversity of external stakeholder involvement aspects of open contribution. The dependent variable innovation outcomes are measured as both internally commercialized new products, with new product performance metrics of speed to market and novelty, and the non-commercialized outcomes of patents and licenses, which can potentially be commercialized subsequently by the firm or by external partners. Since PLS attempts to maximize the explanation of variance of the variable,  $R^2$  values are used to evaluate suitable PLS models (Chin 2010; Echambadi, Campbell, and Agarwal 2006). The  $R^2$  values for model 1 are 0.381 for speed to market, 0.415 for novelty, 0.369 for patents, and 0.337 for licensing. The results are depicted for model 1 in Table 2.

The results provide partial support for  $H_1$ , which predicted the negative effect of diverse external stakeholder involvement during NPD on speed to market but a positive effect on novelty, patents and licensing. Diverse external stakeholder involvement has positive, statistically significant effects at the 0.05 level on speed to market ( $\beta = 0.138, p < .05$ ), novelty ( $\beta = 0.137, p < .05$ ), and patents ( $\beta = 0.237, p < .01$ ), while the effect is marginally statistically

significant for licensing  $\beta = 0.119, p < .10$ ). Thus,  $H_{1a(ii)}$  and  $H_{1a(iii)}$  are supported,  $H_{1a(iv)}$  is partially supported, whereas  $H_{1a(i)}$  is rejected. Similarly, external knowledge search has positive, statistically significant effects on speed to market ( $\beta = .192, p < .01$ ) and licensing ( $\beta = .203, p < .01$ ), while the effect is marginally statistically significant for patents ( $\beta = .139, p < .10$ ) and not significant for novelty ( $\beta = .096, p = \text{n.s.}$ ). Thus,  $H_{1b(iv)}$  is supported,  $H_{1b(iii)}$  is partially supported,  $H_{1b(ii)}$  is in the hypothesized direction but is not significant, whereas  $H_{1b(i)}$  is rejected.

Next, this research establishes the link between open contribution and adaptive marketing capabilities in model 2 by adding the following latent constructs: vigilant market learning, adaptive market experimentation, and open marketing. The  $R^2$  vales for model 2 are 0.448 for vigilant market learning, 0.375 for adaptive market experimentation, and 0.436 for open marketing. The results of model 2 are reported in Table 3. The results provide partial support for  $H_{2a}$  and  $H_{2b}$ , which predicted that diverse external stakeholder involvement and external knowledge search would be positively related to vigilant market learning. External knowledge search is positively related to vigilant market learning ( $\beta = 0.197, p < .05$ ), while the path coefficient from diverse external stakeholder involvement is in the hypothesized direction but not significant ( $\beta = 0.035, p = \text{n.s.}$ ).

The results strongly support  $H_{3a}$  and  $H_{3b}$ , which predicted that open contribution would be positively related to adaptive market experimentation, with statistically significant effects for both diverse external stakeholder involvement ( $\beta = 0.282, p < .01$ ) and external knowledge search ( $\beta = 0.277, p < .01$ ). Conversely, the results do not support  $H_{4a}$  and  $H_{4b}$ , which proposed that diverse external stakeholder involvement and external knowledge search would be positively related to open marketing, with a marginally significant effect for only external knowledge search ( $\beta = 0.120, p < .10$ ). The path coefficient from diverse external stakeholder involvement

to open marketing is not statistically significant although in the hypothesized direction ( $\beta = 0.028, p = \text{n.s.}$ ).

Model 3 tests the direct effects of adaptive marketing capabilities on innovation outcomes. The  $R^2$  values for the dependent variables are 0.596 for speed to market, 0.562 for novelty, 0.460 for patents, and 0.352 for licensing, which illustrates the innovation value to firms that utilize the adaptive marketing capabilities of vigilant market learning, adaptive market experimentation and open marketing. The results for model 3 are depicted in Table 3. The results do not support  $H_{5a}$ ; the relationships between vigilant market learning and each of the innovation outcomes are not significant. However, the results strongly support  $H_{5b}$ ; adaptive market experimentation capability has a positive effect on innovation outcomes. Each of the adaptive market experimentation relationships is statistically significant for speed to market ( $\beta = 0.351, p < .01$ ), novelty ( $\beta = 0.199, p < .01$ ), patents ( $\beta = 0.178, p < .05$ ), and licensing ( $\beta = 0.246, p < .01$ ). In addition, the data support  $H_{5c(i)}$ ,  $H_{5c(ii)}$ , and  $H_{5c(iii)}$ ; open marketing capability has a positive effect on innovation outcomes because the links are statistically significant for speed to market ( $\beta = 0.252, p < .01$ ), novelty ( $\beta = 0.262, p < .01$ ), and patents ( $\beta = 0.297, p < .01$ ). The path from open marketing to licensing is in the hypothesized direction but is not statistically significant ( $\beta = 0.128, p = \text{n.s.}$ ).

### **3.4.2 Mediation Analysis**

After constructing the direct effects models, this study simultaneously analyzes the effects of open contribution on innovation outcomes, open contribution on each of the individual adaptive market capabilities, and each of the individual adaptive marketing capabilities on innovation outcomes. These results are reported in Table 5. Overall, the  $R^2$  values indicate

improved model fit as model 4 (i.e., the mediation model) explains more variance in the dependent variable innovation outcomes than model 1 (i.e., the direct effects model) (Tippins and Sohi 2003). Specifically, the analysis compares the  $R^2$  values for speed to market (0.596 vs. 0.381), novelty (0.562 vs. 0.415), patents (0.486 vs. 0.369), and licensing (0.376 vs. 0.337). Consequently, the study proceeds to empirically test each of the adaptive marketing capabilities as a mediator between open contribution and innovation outcomes.

Mediation analysis tests the role of a third, intervening variable (indirect effects) in enabling the independent variable to influence the dependent variable (Venkatraman 1989). The mediation tests follow the procedure recommended by Zhao, Lynch, and Chen (2010). The indirect effects of both diversity of external stakeholder involvement and external knowledge search through adaptive market experimentation are statistically significant ( $p < 0.05$ ) on the dependent variables of speed to market and novelty. Moreover, neither open contribution variable has a statistically significant direct effect on speed to market or novelty. These results suggest an indirect-only mediation in which the mediated effect exists without the presence of a direct effect (Brady, Voohees, and Brusco 2012; Zhao, Lynch, and Chen 2010). Thus,  $H_{6b(i)}$  and  $H_{6b(ii)}$  are supported.

Also, the indirect effects through open marketing are statistically significant ( $p < 0.05$ ) on the dependent variables of speed to market, novelty, and patents. The only independent variable that has a statistically significant direct effect is diversity of external stakeholder involvement on patents. This analysis suggests that open marketing has an indirect-only mediation for speed to market and novelty, but a competitive mediation for patents (Zhao, Lynch, and Chen 2010). These results support  $H_{6c(i)}$ ,  $H_{6c(ii)}$ , and  $H_{6c(iii)}$ .



However, none of the findings suggest that any of the adaptive marketing capabilities mediate the effect of external knowledge search on licensing. Further, vigilant market learning is not statistically significant ( $p > 0.05$ ) as a mediator, having no effect (Zhao, Lynch, and Chen 2010), so H<sub>6a</sub> is not supported.

In summary, the results of this procedure suggest that adaptive market experimentation capability and open marketing capability mediate the effect of open contribution on innovation outcomes. Specifically, the effects of diverse external stakeholder involvement and external knowledge search on speed to market and novelty show indirect-only mediation by adaptive market experimentation and open marketing. Moreover, the effect of diverse external stakeholder involvement on patents shows a competitive mediation by open marketing.

### **3.5 Discussion and Implications**

While extant open innovation research has primarily centered on searching for and accessing external knowledge with the goal of improving new product development, this study focuses specifically on internal organizational mechanisms that enable firms to realize the benefits of open contribution. This research submits that the incorporation of the dynamic mechanisms of adaptive marketing capabilities are an integral part of a firm's NPD process that can permit the firm to effectively leverage external knowledge that is also available to competitors. Vigilant market learning capability helps firms to sort through ambiguous information to find clues that signal pending market changes. This awareness enables firms to filter through abundant external data to find the relevant knowledge that helps them to anticipate market changes faster and more effectively than competitors (Day and Schoemaker 2005). Adaptive market experimentation capability facilitates systematic, continuous engagement of

external innovation network stakeholders to aid trial-and-error product development efforts that are conducive to rapid learning and the discovery of novel innovations (Day 2011). Meanwhile, open marketing capability helps organizations to monitor and coordinate the flow of knowledge obtained through open contribution to avoid information overload, mobilize extended resources that are accessed through external network stakeholders, and efficiently commercialize innovations (Day 2011). This research supports the notion that firms need to develop and deploy adaptive marketing capabilities to effectively realize the potential benefits that are available through an open contribution approach to NPD.

With the inclusion of adaptive marketing capabilities as mediators in the open contribution empirical model, the classic open contribution variables of external knowledge search and diverse external stakeholder involvement are no longer statistically significant with respect to almost all of the innovation outcomes that are measured in this study. With the inclusion of indirect effects, open contribution has only two statistically significant direct effects, which are both new knowledge outcomes (patents, licensing) rather than new product outcomes (speed to market, novelty). These results suggest that simply advocating open contribution as an innovation strategy alone is insufficient to yield successful commercializable innovation outcomes. Searching externally for knowledge and involving diverse external stakeholders may help the firm learn and generate patents and licensing opportunities, but these outcomes from open contribution do not automatically lead to commercializable new products. In contrast, adaptive marketing capabilities have their strongest effect on the new product outcomes of speed to market and novelty. As a result, firms would be well-served to cultivate and apply the dynamic mechanisms of adaptive marketing capabilities to effectively evaluate, convert, and utilize external knowledge for immediate impact.

When considered in isolation, each of the adaptive marketing capabilities independently mediates the positive effects of open contribution on innovation outcomes. However, when considered simultaneously, adaptive market experimentation capability and open marketing capability emerge as the driving mechanisms to realize innovation outcomes. In particular, these two capabilities are strongly connected with the commercialized new product outcomes of speed to market and novelty. These differences may occur because adaptive marketing capabilities are composed of both exploitation and exploration mechanisms (Day 2011).

Firms have different levels of adaptive marketing capabilities depending on the extent that they focus on exploration or exploitation activities. For instance, vigilant market learning is strongly associated with new knowledge exploration and the discovery of innovation (March 1991). Similarly, external knowledge search and diverse external stakeholder involvement tend to be knowledge exploration activities. In contrast, open marketing capability is more closely aligned with the exploitation of innovative ideas that have more immediate benefits for the organization (March 1991). Meanwhile, adaptive market experimentation exhibits both exploration and exploitation characteristics of innovation. These are internally-led capabilities in that much of the marketing expertise resides within the firm.

Thus, it makes sense that adaptive market experimentation and open marketing are leveraged as the firm orchestrates the development and commercialization of innovations. In fact, one of the core notions of adaptive marketing capabilities is executing strategy in a manner that proactively extends the delivery of innovation value to new customers and channels. This emphasis on implementation concentrates the firm's efforts on taking action to seize the market opportunities that become available through the advance warning systems and deep marketing insights that are generated by adaptive marketing capabilities (Day 2011).

### **3.5.1 Theoretical Contributions**

This essay fills the void regarding the need for empirical studies that measure and link marketing capabilities to open innovation because it offers an empirical assessment of how three specific adaptive marketing capabilities positively influence the innovation performance outcomes of firms that pursue an open contribution paradigm (Day 2011; Krasnikov and Jayachandran 2008; Morgan 2012; Morgan and Slotegraaf 2012). In particular, the Marketing Science Institute advocates understanding marketing capabilities as one of its research priorities in its most recent list of priority topics. This essay fits with this research priority as it is likely the first attempt to operationalize adaptive marketing capabilities, which are particularly relevant to firms that are utilizing open contribution.

Conceptually, this study builds upon the existing framework of marketing capabilities to further define each of the adaptive marketing capabilities and delineate them in the innovation management literature. There are significant relationships between the two dimensions of open contribution and innovation outcomes. However, when the mediating mechanisms of adaptive marketing capabilities were introduced, the hypothesized direct effects became non-significant through the mediating effects of adaptive marketing experimentation and open marketing. Establishing these dynamic marketing capabilities in this domain is a key contribution because it helps explain what happens to external knowledge when it enters a firm's NPD process.

Additionally, this research examines open contribution from an empirical perspective, which is needed in order to advance our knowledge of open innovation and its effects on performance outcomes (West, Vanhaverbeke, and Chesbrough 2006). While there continues to be general enthusiasm for the perceived benefits of open innovation, empirical tests such as those

contained in this study provide a rigorous assessment of open contribution to aid future researchers who scientifically study such phenomena. This perspective expands the current understanding of open innovation by identifying, measuring, and explaining the mechanisms that firms use to convert raw external knowledge into innovations. Notably, this essay focuses on the open contribution aspect of open innovation and delineates it from other forms of open innovation that are more heavily researched. By concentrating on the narrower domain of open contribution, this paper develops our conceptual understanding of how open contribution functions in practice and fits within the broader category of open innovation.

### **3.5.2 Managerial Contributions**

This study offers valuable insights for industry. First, MSI's inclusion of marketing capabilities as a research priority indicates that the results of this research should be of timely relevance to thought leaders in practice. The focus on marketing capabilities is insightful for practice because it advises how firms may initiate organizational change to pursue open innovation. Highlighting the importance of adaptive marketing capabilities to implement open innovation aids business marketing practice by suggesting how firms can purposefully develop the skills needed to uniquely leverage external knowledge that is also available to competitors.

Second, the insights from this study reveal how firms can develop specific capabilities that are needed to implement open contribution and leverage external knowledge during NPD. Frequently, organizations struggle to comprehend, utilize, and respond to the increasing amount of complex feedback that is available from customers and other innovation network stakeholders. The accelerating quantity of external knowledge pouring into firms often results in information overload, an inability to process external information, delayed decision-making, and a failure to

prioritize important tasks (Day 2011). Rather than simply opening proprietary innovation processes to external sources of knowledge that may overwhelm NPD efforts, firms now have guidance on which capabilities they should cultivate in order to evaluate, acquire, codify, and transform external knowledge to achieve specific innovation outcomes.

### **3.5.3 Limitations and Future Research Opportunities**

This essay contains limitations that may be addressed through future research. First, in this study, internal validity is a concern because the analysis makes no preconceived assumptions about causality. As is typical with an exploratory study that uses cross-sectional data, it is unknown whether a firm's open contribution strategy is determined by the considerations that it faces internally, or if the existing external circumstances shape the firm's open contribution strategy. It is possible that the circumstances and strategy are interrelated such that each influences the other. However, causality may be established during a subsequent study in which the performance outcomes are evaluated for new products that are developed using an open contribution strategy. Future research could build upon this study by analyzing panel data to better understand the effects of open contribution over time. This approach should rule out any threat of ambiguity about the direction of causal influence.

Second, this study only looks at the effects of open contribution and adaptive marketing capabilities, but it does not explore the antecedents of what drives firms' change to be more open and how organizations' develop adaptive marketing capabilities to support their open contribution activities. Future research should look at such antecedents. Panel data would be particularly insightful to explore these research questions.

Third, this study focuses only on the open contribution aspect of open innovation and does not explore other facets of the NPD process that may be open. In fact, open innovation phenomena are increasingly open across multiple facets of the NPD process. For example, some firms are using open selection to allow user communities to choose the ideas, which are generated through open contribution, to be developed into new products. Moreover, there are even instances where user communities conduct open contribution and open selection processes independently, without formal governance or transactions with a firm. There are ample opportunities for future research studies to explore these emerging phenomena and help organizations and individuals better understand how they can harness the external knowledge that is increasingly available through open innovation.

In summary, this essay expands our understanding of open contribution by conceptually integrating the firm-level mechanisms of adaptive marketing capabilities to reveal how adaptive marketing capabilities leverage the external knowledge gained through open contribution to achieve innovation outcomes. These extended marketing capabilities capture how the firm uses external knowledge that is gathered through its external stakeholder network to create and protect value (Day 2011). Thus, adaptive marketing capabilities are necessary mechanisms to explain open contribution phenomena.

### 3.6 Tables

**Table 1: Construct Reliabilities and Correlations**

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1.	Adaptive Market Experimentation	1.000											
2.	Diverse External Stakeholder Involvement	0.370	1.000										
3.	External Knowledge Access	0.686	0.119	1.000									
4.	External Knowledge Search	0.401	0.542	0.247	1.000								
5.	Licensing	0.470	0.177	0.461	0.241	1.000							
6.	Market Knowledge	0.681	0.283	0.393	0.176	0.216	1.000						
7.	Market Sensing	0.608	0.408	0.319	0.322	0.219	0.757	1.000					
8.	Novelty	0.596	0.134	0.685	0.140	0.574	0.391	0.355	1.000				
9.	Open Marketing	0.707	0.129	0.713	0.167	0.500	0.468	0.402	0.666	1.000			
10.	Patents	0.561	0.258	0.454	0.240	0.696	0.371	0.364	0.589	0.623	1.000		
11.	Speed to Market	0.687	0.191	0.688	0.241	0.552	0.388	0.326	0.736	0.690	0.578	1.000	
12.	Vigilant Market Learning	0.753	0.273	0.564	0.336	0.412	0.666	0.564	0.563	0.619	0.528	0.610	1.000
$\alpha$		0.840	0.872	0.932	0.779	---	0.909	0.911	---	0.868	---	---	0.951
$\rho$		0.880	0.893	0.967	0.895	---	0.933	0.938	---	0.919	---	---	0.958
AVE		0.597	0.461	0.936	0.810	---	0.735	0.790	---	0.791	---	---	0.720
$\alpha$ = Cronbach's alpha measure of internal consistency reliability $\rho$ = Composite reliability measure of internal consistency reliability AVE = Average variance extracted by the construct													



**Table 2: Direct Effects – Model 1**

Exogenous Variables	Model 1 Open Contribution to Innovation Outcomes			
	Dependent Variables			
	Speed to Market	Novelty	Patents	Licensing
Diverse External Stakeholder Involvement	0.138**	0.137**	0.237***	0.119*
External Knowledge Search	0.192***	0.096	0.139*	0.203***
R <sup>2</sup>	0.381	0.415	0.369	0.337

Path coefficients \* $p < 0.10$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.001$

**Table 3: Direct Effects – Model 2 and Model 3**

Exogenous Variables	Model 2 Open Contribution to Adaptive Marketing Capabilities			Model 3 Adaptive Marketing Capabilities to Innovation Outcomes			
	Dependent Variables			Dependent Variables			
	Vigilant Market Learning	Adaptive Market Experimentation	Open Marketing	Speed to Market	Novelty	Patents	Licensing
Diverse External Stakeholder Involvement	0.035	0.282***	0.028				
External Knowledge Search	0.197**	0.277***	0.120*				
Vigilant Market Learning Capability				0.101	0.113	0.122	0.011
Adaptive Market Experimentation Capability				0.351***	0.199***	0.178**	0.246***
Open Marketing Capability				0.252***	0.262***	0.297***	0.128
R <sup>2</sup>	0.448	0.375	0.436	0.596	0.562	0.460	0.352

Path coefficients \* $p < 0.10$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.001$

**Table 4**

Exogenous Variables	Model a Vigilant Market Learning				Model b Adaptive Market Experimentation				Model c Open Marketing			
	Dependent Variables				Dependent Variables				Dependent Variables			
	Speed to Market	Novelty	Patents	Licensing	Speed to Market	Novelty	Patents	Licensing	Speed to Market	Novelty	Patents	Licensing
Diverse External Stakeholder Involvement	0.071	0.083	0.184**	0.093	-0.002	0.034	0.148*	0.059	0.088	0.091	0.192**	0.094
External Knowledge Search	0.086	0.004	0.065	0.168**	0.410	-0.025	0.043	0.139*	0.121*	0.037	0.081	0.170**
Vigilant Market Learning Capability	0.399***	0.340***	0.285***	0.135**								
Adapt. Market Experimentation Capability					0.539***	0.416***	0.334***	0.221***				
Open Marketing Capability									0.504***	0.435***	0.419***	0.238***
R <sup>2</sup>	0.489	0.494	0.422	0.348	0.560	0.522	0.435	0.365	0.541	0.534	0.479	0.373

Path coefficients \* $p < 0.10$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.001$

**Table 5: Test of Mediating Effects – Model 4**

Model 4 (Final)							
Exogenous Variables	Dependent Variables						
	Vigilant Market Learning	Adaptive Market Experiment.	Open Marketing	Speed to Market	Novelty	Patents	Licensing
Diverse External Stakeholder Involvement	-0.042	0.217**	-0.069	0.012	0.047	0.160**	0.065
External Knowledge Search	0.191**	0.283***	0.122	0.044	-0.024	0.050	0.148**
Vigilant Market Learning Capability				0.094	0.118	0.102	-0.013
Adaptive Market Experimentation Capability				0.310***	0.168**	0.063	0.125
Open Marketing Capability				0.274***	0.278***	0.335***	0.171*
R <sup>2</sup>	0.345	0.194	0.230	0.596	0.562	0.486	0.376

Path coefficients \* $p < 0.10$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.001$

## **Chapter 4**

### **Nonmarket Innovation: Community Selection of Independently Created**

#### **Product Designs and the Moderating Role of Designer Reputation**

##### **4.1 Introduction**

Historically, consumers visit retailers to search for products that are created by manufacturers and service providers (Rindfleisch 2014). Firms create value by offering products, while the market serves to exchange this value with consumers (Prahalad and Ramaswamy 2004a). Consumers are passive participants in this exchange process, selecting products from a narrow range of choices that are pre-determined by firms (Prahalad and Ramaswamy 2004b).

However, a greater number of consumers now engage in processes of both defining and creating product value, which is blurring the traditional distinction between production and consumption activities (O'Hern and Rindfleisch 2010; Prahalad and Ramaswamy 2004a). For example, a recent survey finds that nearly 2.9 million individuals in the United Kingdom alone have created or modified a product for their own consumption during the past three years (von Hippel, de Jong, and Flowers 2012). Moreover, consumers exhibit a growing ability and willingness to experiment with other consumers in creating new products without any formal oversight from firms (Prahalad and Ramaswamy 2002). As a result, consumers now have the choice of whether to buy a finished product using the traditional market-based system, or independently create their own design as part of “the maker movement” (Rindfleisch 2014). Consumers who choose to independently create their own designs are called “makers” because they create new products rather than searching for and purchasing existing products from a supplying firm.

The maker movement is exemplified by nonmarket innovation, which is a process whereby independent users create and freely share new product designs, and subsequent users are able to select the product designs for adoption. With this type of open innovation, consumption and production are no longer separate economic activities because individual users actively create designs as they consume the product in the absence of influence by firms. The creation of product designs by users instead of firms is termed “independent nonmarket production” (Benkler 2006), which is comprised of individuals who each create products for the purpose of their own use (Baldwin and von Hippel 2011). These “consumer-creators” benefit through consuming the innovations that they develop, as opposed to “producer innovators” that benefit from selling the innovations that they develop (de Jong and von Hippel 2009). The questions of how and why individuals develop original content and freely share their innovative talent are discussed in the open source software literature (Grewal, Lilien, and Mallapragada 2006; von Hippel and von Krogh 2003) and in the social production literature (Benkler 2006). However, the availability of socially-produced designs has given rise to a new type of *consumer* that can adopt and make her own products through nonmarket innovation instead of using a traditional market-based exchange system. This essay builds upon our knowledge of social production to investigate how individuals select products that are designed via nonmarket innovation.

One such element that enables nonmarket innovation is community selection, which is the system whereby consumers collectively evaluate and individually select particular product designs for their own use. The community selection process evaluates design attributes along the dimensions of granularity and modifiability. From a social production perspective (Benkler 2006), granularity encompasses the costs of producing a product that has been digitally designed

through nonmarket innovation. The current study submits that individuals select designs that have lower granularity because such designs have lower costs of production. On the other hand, this study suggests that individuals select designs that have a higher potential to be modified because they can customize the design to their personal preferences. Even though modifying an existing design requires more effort by the user to create the product prior to consumption, individuals who participate in nonmarket innovation particularly enjoy the freedom of adapting product designs to their individual tastes.

Additionally, community selection features a method of allowing members to review designs. Community review is a mechanism that permits community members to comment on and vote for ideas that are submitted by other external contributors (Bayus 2013). Each vote and comment leaves evidence that assesses the value of each new idea for other community members to use as they decide whether to select the new idea. Without a system of community review, users would each have to try out individual product designs through an inefficient, repeated iteration of trial-and-error. Instead, the community review mechanism allows the community to share knowledge, build upon one another's ideas, and easily welcome new members to the community by making the selection of new designs more accessible.

Further, community selection functions, in part, due to the accumulating reputation of individual designers that share their original product designs. The vast majority of nonmarket innovation product designs are created by anonymous individuals rather than by professional firms. As a result, product designs that originate from nonmarket innovation do not carry the typical marketing features such as brands, logos, recognizable packaging, warranties, and other quality signals that are managed by firms with the purpose of increasing consumers' confidence in trialing a product. As an alternative to such market signals that consumers seek when

evaluating products, the community selection system leaves evaluation information about designers in addition to review information about each design. The designer's reputation is an indicator of standing within the community that spills over onto the expected quality of the designer's original product designs. As a result, this community feedback about designers enhances individual users' ability to select independently created designs for adoption.

Nonmarket innovation is expanding at a rapid rate because individuals are becoming more competent at innovating, technology is becoming available that facilitates social production, and communities are emerging where individuals help each other innovate and build on each other's ideas (Benkler 2006). Firms are taking notice of nonmarket innovation activities because they are encroaching on their established market share. These nonmarket innovation communities are becoming proficient enough to offer products that compete with and displace incumbent firm-supplied products (de Jong and de Bruijn 2013). In particular, additive manufacturing, commonly known as 3D printing, is a rapidly growing example of nonmarket innovation in which individual contributors "share the work of generating a design and reveal the outputs from their individual and collective design efforts openly for anyone to use" (de Jong and de Bruijn 2013). Firms are unable to ignore the emergence of this phenomenon because of the magnitude of its presence. The 3D printing market size was estimated to be \$1.2B in 2010 and is expected to swell to \$5.2B by 2020 (Rindfleisch 2014; Ryan 2011).

Up to this point, the corporate reaction to the swift development of 3D printing nonmarket innovation communities has been mixed. Some firms assess 3D printing as a disruptive technology that threatens to upset their core business. This initial reaction is expected given that consumer-created innovations identify gaps in existing market offerings from incumbent manufacturers and retailers (de Jong and de Bruijn 2013). For example, leading



logistics firm DHL recently released a paper on how 3D printing will impact its business, including a telling quote from their vice president of innovation and product incubation, “If these products are printed locally, there isn’t the requirement to ship them halfway around the world” (DHL Supply Chain 2013). Consequently, innovation by individual users and open communities of collaborators will increasingly compete with traditional corporate innovation activities, erode the incumbents’ market share, and, in some cases, even displace traditional organization-led innovation (Baldwin and von Hippel 2011; de Jong and de Bruijn 2013).

However, other firms’ realize that these social production communities are an underutilized domain of external knowledge that firms can interact with and learn from (de Jong and de Bruijn 2013). The freely available posting of innovative ideas via nonmarket innovation represents an opportunity for forward-looking firms to discover novel ideas as well as influence future products that may be adopted by consumers by offering firm-created designs. In other words, these companies may build upon the freely-available, user-generated ideas to manufacture and offer the next generation of products that are of higher quality and/or lower cost (de Jong and de Bruijn 2013). This strategy is defensible since prior research indicates that firms that monitor the adoption of user-innovations by consumers are able to obtain superior projections of potential market sizes and future product sales (von Hippel 2005).

Regardless of whether a particular firm views nonmarket innovation as a threat or an opportunity, both types of firms are interested in knowing what determines a positive consumer response for nonmarket innovations. Consumers choose designs for reasons that may be driven by attributes of the design itself, such as how easily the product may be used or modified. Other consumers’ selection decision may be influenced by the designer’s reputation if the designer has a strong standing within the user community. Theoretically, there is a need to investigate the

phenomena of nonmarket innovation in order to advance our understanding of what drives users and communities of users to select products that are created in this domain. From a managerial perspective, the ability to decipher which designs will be adopted by future consumers offers powerful insight that firms can use for adapting to and harnessing the disruptive force posed by nonmarket innovation. Consequently, this essay seeks to answer the following research questions:

- Under what conditions do product design attributes increase the likelihood that users select product designs that are created and evaluated via nonmarket innovation?
- Under what conditions does the reputation of the product designer moderate the likelihood that users select product designs that are created and evaluated via nonmarket innovation?

This essay seeks to make the following contributions. Theoretically, this essay expands social production phenomena to include the system of community selection, and it integrates the social production perspective into the marketing domain. Marketing scholars are particularly concerned with unpacking the behavior that drives the diffusion of new products. Yet the nonmarket innovation domain resides outside the boundaries of our existing knowledge base that is focused on the consumption of firm-supplied goods that are exchanged via traditional marketplace transactions. This study extends the reach of the social production perspective by incorporating the design attributes of granularity and modifiability into our understanding of how selection occurs with nonmarket innovation. Further, this essay makes a theoretical contribution by explicating the nonmarket innovation process to include the element of community review

and the moderating role of designer reputation that influences users' decision to select freely shared designs.

Empirically, this essay tests community selection as the process that guides the individual selection choice of nonmarket innovation users. The social production measures of design granularity and design modifiability are operationalized and tested as antecedents to user selection. Additionally, designer reputation is operationalized in the nonmarket innovation domain and tested as a moderating influence on user selection. Notably, this research uses a multi-method approach that leverages the use of secondary data from a 3D printing user community, behavioral lab data that isolates specific community selection mechanisms, and survey data from users that have actually engaged in 3D printing designs that are created via nonmarket innovation.

Substantively, the empirical results of this research have implications for managers that seek to understand the emerging behavior of consumer-creators and how they may disrupt traditional markets that are dominated by firms. Organizations are just beginning to dabble in 3D printing nonmarket innovation communities. Thus, having advanced knowledge of what drives selection behavior provides insights for how firms can participate in such communities by offering their own original designs, or understanding how to defend their markets from encroachment by such products.

The remainder of the essay is organized as follows. Section 2 explicates the social production perspective, with a specific focus on delineating nonmarket innovation, consumer-creators, and the maker movement. Then, sections 3 and 4 extend our knowledge of social production to integrate the process of community selection as the mechanism that guides the individual user selection decision of product designs that are created by independent nonmarket

production. In particular, the concepts of design granularity, design modifiability, and designer reputation are employed to hypothesize why particular independent nonmarket designs are more likely to be selected by subsequent users. Sections 5 through 8 describe the methodology, empirical context, data collection, analysis, and results. Finally, Section 9 concludes the paper by offering theoretical, empirical, and managerial implications.

## **4.2 Social Production**

This essay draws upon the emerging perspective of social production (Benkler 2006). Social production is a process in which individuals, and loosely connected communities of individuals, create new products through voluntary, separate contributions without the oversight of any formal governing body (Benkler 2006). Classic examples of social production include open source projects (von Hippel and von Krogh 2003) and Web 2.0 platforms (Hoegg et al. 2006). Social production is discernible by the core characteristics of decentralization and the use of social norms to motivate and coordinate individual contributions (Benkler and Nissenbaum 2006). Decentralized social producers independently develop and share innovations in the absence of both the hierarchical supervision of direct corporate oversight and the incentives of traditional market transactions (Gruen, Osmonbekov, and Czaplewski 2007).

An essential feature of social production is voluntary self-selection (Benkler and Nissenbaum 2006). “Self-selection” means that individuals are empowered to decide whether and how to allocate their time and talent in order to complete a particular innovation activity (Benkler 2002). An example of voluntary self-selection is lead user innovation in which consumers attempt to innovate to fill their own emergent needs that are unmet by an existing

product (von Hippel 1986). Each person's ability to innovate is highly variable across the individual capability and willingness to provide effort (Benkler 2002).

Social production is able to occur without hierarchical supervision because individual contributors voluntarily self-identify innovation tasks that they can perform based upon a high level of personal knowledge about their own skills. Individuals are motivated to contribute without clear lines of hierarchical authority because they can match their own skills and resources to tasks that they are interested in completing. Individuals are free to contribute as much content as they want, whenever they decide to commit their own time and capabilities toward developing new content. Thus, social production represents a decentralized, widely distributed style of developing new products (Benkler 2002).

#### **4.2.1 Social Production and Property Rights**

Social production is a divergence from traditional market-based and hierarchy-based modes of production in which goods are manufactured and distributed by firms (Benkler 2006). Firm-organized systems of innovation and production rely upon property rights over their innovations and market exchange transactions to sell their products to consumers (Benkler 2002). Such firms that develop new products through closed new product development (NPD) processes have also been described as “producer innovators” because they innovate without collaborating externally and have exclusive control over the resulting intellectual property (Baldwin and von Hippel 2011). Property rights and market exchange mechanisms enable producer innovators to control access to and profit from proprietary intellectual property.

These industrial economy production approaches are often analyzed by transaction costs economics (TCE) theory (Rindfleisch 2014; Williamson 1975, 1985). TCE assumes that

products are made by firms that compete with each other, and that transactional choices are based upon concerns for opportunism, monitoring, and contract enforcement (Rindfleisch and Heide 1997). In contrast, participants in social production “cooperate, build upon the work of others, contribute time, effort and expertise to create and enhance a public good” without any payment made to those individuals in return (Benkler and Nissenbaum 2006). Individuals engaged in social production disclose their innovations freely, so they have little to no need for monitoring and enforcement compared to market-based transactional frameworks (Benkler 2006). Consequently, these social production and consumption choices have implications for marketing theory and practice that reside beyond the scope of TCE theory.

Social production avoids the property rights and transaction costs that are associated with firms and markets, which serve to limit the access of resources and people to each other (Benkler 2002). Socially produced products are made freely available for consumption by the general public. Since the innovation outputs are widely accessible without market transactions, property rights become a minor, or nonexistent, consideration by developers of the new product. As a result, individual contributors are able to freely share knowledge with each other in order to further innovation efforts that are motivated by their common interest. Consequently, social production systems reduce the barriers to individual contribution, which has the effect of increasing the potential universe of individuals that can participate in the NPD process (Lakhani and Panetta 2007). A summarized comparison of the major differences between TCE and social production is found in Table 6.

#### **4.2.2 Peer Production**

Social production includes two forms of decentralized NPD phenomena: 1) peer production, and 2) independent nonmarket production (Benkler 2006). Peer production is a system of innovating among large groups of individuals who collaborate to develop new products without utilizing traditional market transactions for knowledge exchange or the hierarchical governance of a firm for organizing and directing their innovation activities (Benkler 2002; Benkler and Nissenbaum 2006). Wikipedia and open source software (OSS) communities are two of the most well-known examples of peer production systems in which individuals self-select participation, self-organize collaboration, and make their innovation outputs freely available for integration into a larger project (Lakhani and Panetta 2007; Mallapragada, Grewal, and Lilien 2012). As a social production system, peer production relies upon decentralized exchange of knowledge and human creativity (Benkler 2002).

A notable feature of peer production is that individuals collaborate on tasks that are part of a common, larger project. In both Wiki and OSS communities, multiple participants work on small parts that contribute towards development of a larger central project, with numerous iterations of communication between contributors as the project progresses (Baldwin and von Hippel 2011). This is a collaborative approach to innovation that entails coordination by contributors, and it often requires the administration of a project maintainer or project manager. While this position is typically also a volunteer, this role exists to improve coordination of the contributions into the central project. Once the central project is completed, the innovation output is typically released to the general public for its free consumption and further development.

### **4.2.3 Independent Nonmarket Production**

The second form of social production, independent nonmarket production, is completed by individual consumers that design new products in the absence of influence by firms. Independent nonmarket production provides an opportunity for consumers to be actively engaged in the creation of a new product as they consume it (Benkler and Nissenbaum 2006). This is a contrast from typical consumption processes that are more passive, such as browsing among available product choices that are offered by supplying firms. With this type of open innovation, consumption and production are no longer separate economic activities because individual users actively create new products to meet their own consumption needs. As a result, these users are sometimes referred to as “consumer-creators” because they consume as they innovate. Consumer-created innovations identify gaps in existing market offerings that are provided by incumbent manufacturers and retailers (de Jong and de Bruijn 2013).

The term “independent nonmarket production” signals its difference from the traditional, industrial economy production approaches of market-based and hierarchy-based modes (Benkler 2006; Rindfleisch 2014). Typically, innovations by consumer-creators do not enter the marketplace in which goods are produced, offered at a price, and exchanged through monetary transactions. These individual creative talents are not mobilized by money. Instead, according to the theory of social capital, consumer-creators are motivated by social relations to mobilize and share their resources (Benkler 2006).

Independent nonmarket production is different from peer production because participants create numerous finished products rather than collaborating on a central project. Prior research indicates that rational innovators that do not compete with each other will choose peer production over independent nonmarket production to create a nonrival good in which each



contributor receives the value of the whole product while bearing only a portion of the development effort (Baldwin and Clark 2006; Baldwin and von Hippel 2011). However, consumer-creators choose independent nonmarket production because they do not work on a central project in which they receive a whole value of a design while only bearing a portion of the design cost.

Further, independent nonmarket production is different than lead user innovation because lead users typically start with a firm-produced offering as an initial reference point and modify the existing good to create solutions that meet their own emergent needs (von Hippel 1986). In contrast, the independent nonmarket producers spawn completely new products with original product designs that typically are not based upon an obtainable manufacturer's design. Thus, independent nonmarket production is completely separated from the traditional, transactional economy. This departure from the transactional economy is epitomized by the emergence of a culture in which people prefer to make products for themselves rather than buying off-the-shelf products that are supplied by firms. This emerging culture, termed the "maker movement" is further described in the next section.

#### **4.2.4 The Maker Movement**

The maker movement is a rapidly emerging area of nonmarket innovation in which individuals create original product designs, and communities of users select and adopt designs without the use of market transactions. In particular, communities of 3D printing users are an exemplar of the maker movement because individual consumer-creators voluntarily create, upload, and share new product designs while bypassing traditional markets, retailers, and manufacturers. It is no coincidence that a popular brand of 3D printer models carries the name

MakerBot. Consumer-creators who choose to join “the maker movement” are able to bypass retailers and manufacturers, and their market-based transactions (Rindfleisch 2014).

The foundation of the maker movement evolves from the do-it-yourself (DIY) culture (Dougherty 2012). Consumers that prefer DIY formats are actively engaged in the co-production of products for their own consumption (Etgar 2008). People who choose to make objects and provide services for themselves do so to learn new skills, enrich their lives, and experience the joy of creating something new (Dougherty 2012). Consumer-creators are part of this DIY culture, as they prefer to create unique innovations for their personal consumption rather than buying an off-the-shelf product supplied by a firm.

Similarly, the maker movement entails DIY digital product designs that still require effort on the part of the individual consumer to produce a usable product. In essence, a design is a fundamental set of instructions that represent “a recipe for accomplishing the functional requirements” to produce a specified product (Baldwin and von Hippel 2011). If the finished product is electronic, such as software, then the product design is essentially the same as the usable form of the product itself. However, if the product must take a physical form to be consumed, as is the case with 3D printing, then the design instructions must be executed to create the usable product (Baldwin and von Hippel 2011). The 3D printer converts the electronic design to a physical product, enabling consumers to make their own tangible products.

#### **4.3 Community Selection of Independent Nonmarket Product Designs**

Social production phenomena exhibit how individuals, and communities of individuals, can *produce* goods without using traditional market-based and hierarchal-based modes of governance. However, little is known about how consumers *select* product designs that are

created through independent nonmarket production. This chapter is particularly concerned with investigating user selection of such product designs in order to develop the social production perspective and extend it into the marketing domain. As such, this section seeks to expand our knowledge of social production to understand the process of nonmarket innovation, which includes both the creation of original designs through independent nonmarket production, and the system of community selection that influences the diffusion of product designs that are developed independently without the use of markets.

#### **4.3.1 Nonmarket Innovation**

The nonmarket innovation process can be decomposed into the two steps of independent nonmarket production and community selection. The first step, independent nonmarket production, includes the process of self-identification of tasks in which individuals voluntarily create and share original product designs. The development of innovations through voluntary contributions, as well as the motivations for why individuals elect to participate in such communities, has been studied in the social production context (Benkler 2002; Baldwin and Clark 2006). The second step, community selection, is the system that consumers use to choose particular designs for their individual use. Community selection is relatively understudied and is the focus of this section.

#### **4.3.2 Community Selection**

Since individuals who engage in independent nonmarket production are not in competition with each other, they often form communities of “voluntary collective groups” around a common interest in order to share, improve, and build upon each other’s product

designs (Baldwin and Clark 2006). In such communities, all social production systems need a “robust system for peer review” to remove inadequate contributions from participants that misjudge their own skill level (Benkler 2002). For example, the peer review process for an OSS project may include the lead project maintainer and a core group of developers that have a long history with the project and have built trustworthy reputations.

Social production only works if the “system develops some mechanism to filter out mistaken judgments that agents make about themselves” (Benkler 2002). If any subcomponent is erroneously completed by an individual but subsequently inputted into a communal central project, the poor quality of the subcomponent will effectively reduce the overall value of the entire final product. There must be a method for the community to weed out the low quality contributions from participants that incorrectly match their skills and resources to product development tasks (Benkler and Nissenbaum 2006).

Thus, a successful social production process must have a low-cost method of reviewing the quality of contributions and integrating the individually-completed component tasks into the larger project (Benkler 2002). Integration consists of a mechanism for monitoring and assuring the quality of individual contributions and a mechanism for combining the individually contributed tasks into a larger project (Benkler and Nissenbaum 2006). However, independent nonmarket production phenomena are different from peer production phenomena because there is no central project that a community is working towards completing. Each task is not accomplished as a small part of a much larger whole project. Independent nonmarket production does not require a mechanism for combining subcomponents since each innovation is initially produced in isolation as a standalone finished product. Consequently, there is no core group of project maintainers or editors that oversee the quality of contributions. This limits the influence

of a central moderator to alter the aggregate judgment of the user community. Instead, each individual user independently creates and shares content with the rest of the community for their own consumption.

Nonetheless, nonmarket innovation community members still attempt to improve the quality of the content that is individually contributed. With nonmarket innovation, the contribution step only represents the initial creation of a new product design by an individual that innovates for personal consumption. However, the initial contribution does not include the design's subsequent use by other consumers within the community. In other words, while the individual choice to participate in a nonmarket innovation community is quite open, all contributions are not guaranteed to be used by other consumers within the community. Thus, a quality control mechanism is highly relevant to nonmarket innovation. This mechanism is community selection.

Community selection is an emerging system that is utilized to determine the success of products designed via independent nonmarket production. Community selection allows community members to comment on and vote for ideas submitted by other external contributors (Bayus 2013). This form of selection system enables nonmarket innovation to leverage the aggregation of frequent small judgments, rather than relying on an expert group of moderators as is typically used with peer production (Benkler 2002).

Additionally, community selection includes the choice of which product designs that users select for their individual consumption. Consumers of 3D printable products select digital designs that they still must physically produce prior to use. The good is not finished when they select it. They can view, download, print, and attempt to modify or build upon the original design. The finished product design may be used by subsequent individuals that choose not to

alter the creator's original design. Alternatively, the individual may select the initial design but modify it to meet her consumption preferences. Few studies have investigated why consumers select certain designs among the large volume of designs that are contributed. The influence of these design attributes on selection behavior is the topic of the next two sections.

#### **4.3.3 Granularity and Selection of the Unaltered Product Design**

Users may select new product designs for several reasons. Some individuals may select designs due to favorable attributes about the finished design itself. For example, 3D product designs are more likely to be selected if they are easy to re-produce during the physical printing process (de Jong and de Bruijn 2013). Consumers may desire convenience, such that a particular design seems easy to print, includes detailed printing instructions, or cannot be immediately purchased through a known retail channel (Rindfleisch 2014).

An important consideration with nonmarket innovation is that the selection decision includes a cost of production. The electronic design is information that is essentially a recipe to produce a physical product (Baldwin and von Hippel 2011). Before the product can be utilized, the digital design must be converted to a physical form by a 3D printing medium, which carries production costs related to time, effort, and materials. These individual costs of production are related to the social production concept of granularity, which describes the amount of resources, time, and effort that individuals invest to create the product (Benkler 2006).

With social production, participants can contribute to an NPD project in small or large increments. The key to determining participation is the granularity that enables potential contributors' self-selection to complete the social production tasks (Lakhani and Panetta 2007). When a project is broken into very small pieces that can be performed in a short period of time

by a skilled contributor, then an individual is more likely to volunteer to complete the task (Benkler 2002). Granularity sufficiently decomposes problems to become small enough in scope that individuals can attempt to complete portions of the project based upon their own unique skills, capabilities, and time (Lakhani and Panetta 2007). In other words, granularity works to define the limits of the problem, limits the cost of participation for individual contributors, and helps assure potential contributors that they will not spend an excessive amount of time attempting to complete the item (Lakhani and Panetta 2007). Thus, granularity is concerned with minimizing the cost of completing tasks by contributors (Lakhani and Panetta 2007).

With nonmarket innovation, individual consumers face similar considerations of granularity when selecting a design to print. Designs with low granularity have a lower cost of production in terms of time to print and material costs. If granularity is too high, then the pool of potential users decreases because of the high requirement of time and effort to use a design (Benkler 2002). Individuals will choose products with high net benefits, which include the “consumers’ perceptions of the product’s relative advantages and risks” (Moreau, Lehmann, and Markman 2001). Granularity reflects the relative risks of how much individual effort is allocated to attempting to print an electronic design.

Each design’s value must exceed its cost of creation. The cost is determined by the individual contributors, who self-select the completion of designs based upon their own talents and resources. A consumer-creator will self-select to create a new design if the expected value that the individual will receive from the enjoyment of the design process and subsequent consumption of the innovation is greater than the individual’s cost of designing a new product, in terms of their time and effort (Baldwin and von Hippel 2011). The same process occurs for consumer-creators as they adopt existing finished designs. They select products in which the

expected cost of printing the electronic design is lower than the expected value of printing and using the physical object.

According to the social production perspective, the granularity of new product designs helps to determine the choice for whether goods are produced through socially-based approaches instead of through the traditional hierarchy-based or market-based modes (Benkler 2006). Social production attempts to reduce the costs for individuals to participate in the NPD process such that an increased number of contributors can self-select into the community (Lakhani and Panetta 2007). Similarly, more consumers will select a design if the individual costs of selection are lower than alternative products. Creating a product design with lower granularity increases the potential universe of users of the finished product. Therefore, this study hypothesizes:

H<sub>7</sub>: Individual users are more (less) likely to select unaltered independent nonmarket innovations with lower (higher) design granularity.

#### **4.3.4 Modifiability and Selection of the Product Design**

An appealing feature of nonmarket innovation is that consumers can tailor products to suit their tastes. Some users may select a particular existing product design because they are able to modify it, or build upon the original design in order to customize it to meet their individual consumption preferences (Rindfleisch 2014). The notion of individuals building upon the existing work that is freely shared by other contributors is related to the concept of “modularity” that is found in social production. Modularity describes the extent to which a socially produced item can be decomposed into smaller components that can be independently produced before assembly into a finished product (Benkler 2006).



With peer production, modularity has a connotation of assembly, which is appropriate for activities in which developers work in parallel on small parts of a larger project. However, assembly is not required with nonmarket innovation because there is no central project that individual contributors are working towards completion. Nonetheless, individual consumers can still attempt to build upon another contributor's design, which requires product design modifiability.

With nonmarket innovation, modifiability enables individuals to self-direct their innovation efforts because the individual designs can be produced by “different people, with different capabilities, at different times” (Benkler 2002). Design modifiability provides opportunities for contributors to exchange their work with each other and build upon others' designs without ongoing communication between contributors. Designs that are modifiable are able to be altered independently if they follow certain design conventions that permit subsequent consumer-creators to understand and build upon the initial design (Baldwin and Clark 2006). Design modifiability facilitates later product iterations because changes can be made easily through small contributions by other users. Further, design modifiability serves to improve the transparency of each contribution to make the potential for modification visible to subsequent users (Baldwin and von Hippel 2011).

The modifiability of digital products is one reason for the increasing growth of 3D printing and its anticipated competition with organizational innovation efforts (de Jong and de Bruijn 2013). The nonmarket innovation approach to designing 3D printable products is appealing because design modifiability attracts voluntary contributions from subsequent users. Such modifiability appeals to individual users because they are able to adapt a design to make a product that meets their unique needs. As a result, in certain aspects of the digital economy,

nonmarket innovation is replacing market-based and hierarchy-based modes of production. Individuals that are part of the maker movement are able to select products to modify for their own consumption. They select particular designs because they want to use the final product that is created and because they enjoy the process of making a new product (Rindfleisch 2014). Therefore, this study hypothesizes:

H<sub>8</sub>: Individual users are more (less) likely to select independent nonmarket innovations with higher (lower) design modifiability.

#### **4.4 Moderating Influence of Designer Reputation**

A notable difference between nonmarket innovation and producer innovation is that an individual designer's initial new product design tends to be a relatively anonymous creation. Since anyone can contribute nonmarket innovation designs freely, the participants in a community often do not know each other. In contrast, producer innovators offer new products that are attached to a broader brand that indicates a particular product quality, positioning, and other psychological attributes. Such brand anchoring and quality signals are not required to share designs within nonmarket innovation communities. As a result, many of the marketing levers, such as brands and packaging, which consumers are accustomed to using when they evaluate products are missing when they evaluate whether to select an independently created digital product design.

Adoption of a new product is easier if the design is accompanied by relevant supplementary information, which helps consumers to understand the design and appreciate higher perceived net benefits (Moreau, Lehmann, and Markman 2001). Since nonmarket innovations are designed independently rather than purchased through a known retailer,

supplementary information can be particularly important to increase perceived quality of the product design and spur the selection decision. The importance of a product source's reputation is magnified in an online environment because many of the service dimensions that are available in a brick and mortar environment are not visible to online consumers (Rust and Chung 2006). Supplementary information from the source of the digital product design may increase the consumer's comprehension of the product, its risks, and its benefits (Moreau, Lehmann, and Markman 2001).

In the case of nonmarket innovation, an important source of supplementary knowledge is the reputation of the designer. The community selection provides provides supplementary information to users regarding the designer, which influences users' expectations of the design's quality. As initial community members vote for and comment on the designer's designs, a trail of information is shared that helps subsequent consumers decide which designers are creating the most desirable product designs to select for their own use. Additionally, as assessments are made about designs, the designer accumulates a positive or negative reputation that influences the subsequent design selection decision of other users in the community.

While users select designs based upon their perceptions of the attributes of the design itself, their decision may also be influenced by the reputation of the designer. With nonmarket innovation, using an independently created design entails significant risk since there is typically an absence of a known brand, manufacturer, or retailer to stand behind the quality of the product. The designs are offered freely, so there is no organization to return the product to if it fails to print or fails during use. However, if the source of the design is perceived to be trustworthy, then the positive effects of source credibility may ease concerns about adopting the design (Moorman,

Deshpande, and Zaltman 1993). Thus, a positive designer reputation may serve to reduce the consumer's perceived risk of selecting a nonmarket innovation.

Individual designers who offer a high number of product designs tend to develop favorable reputations within a particular nonmarket innovation community. The volume of designs increases the credibility of all of her designs because this product portfolio reflects an accumulated experience with designing and printing 3D products. The designer's experience may be interpreted as expertise, which improves the potential users' appraisal of the designer's trustworthiness and credibility (Moorman, Deshpande, and Zaltman 1993). Further, if users have a positive experience with printing one design from a particular designer, they may feel less risk about printing a different design that was created by the same designer. Thus, existing consumer knowledge about the product and innovation continuity positively influences the adoption decision (Moreau, Lehmann, and Markman 2001).

As part of the community selection process, a small proportion of select individual designers acquire sufficient standing among the 3D printing community that they have a number of "followers" that like the particular designer. A "follower" is a distinction designated by consumers, and it reflects a high compliment to the actual designer that is above and beyond each unique product design. This follower phenomenon mirrors prior research that indicates that 3D printer designs are more likely to be selected if the designer is well-connected within the user community (de Jong and de Bruijn 2013). Thus, the positive reputation of the designer serves to increase the probability that other users will choose products that are created by that particular designer. Therefore, this study hypothesizes the following moderating relationships:

H<sub>9a</sub>: A higher (lower) reputation of a designer of independent nonmarket innovations

i) amplifies (lessens) the positive effect of low granularity, and ii) lessens (amplifies) the negative effect of high granularity, on the likelihood that individual users will select the product design.

H<sub>9b</sub>: A higher (lower) reputation of a designer of independent nonmarket innovations

i) amplifies (lessens) the positive effect of high modifiability, and ii) lessens (amplifies) the negative effect of low modifiability, on the likelihood that individual users will select the product design.

An overview of the conceptual research framework, which tests the effects of design attributes and designer attributes on individual user selection, is depicted in Figure 2. The hypotheses are summarized in Table 7.

## **4.5 Study 1 – Web Scraping Secondary Data**

### **4.5.1 Research Design Methodology Overview**

Study 1 tests the hypotheses by utilizing secondary data from a popular 3D printing community. 3D printing is a rapidly emerging nonmarket innovation context due to the low-cost of Internet-based design and communication of products, combined with the efficiency achieved by the increased product design capability of better-educated individual contributors (de Jong and de Bruijn 2013). 3D printing communities engage in sharing original electronic designs that may be printed by others in unaltered form, or modified by other consumer-creators and printed. This medium is predominantly used by individual designers that independently create designs for

their personal consumption. This context offers secondary data that enables the objective, transparent observation of community selection in practice.

#### **4.5.2 Data Collection Procedure**

This essay uses secondary data that are publicly available from the Thingiverse website ([www.thingiverse.com](http://www.thingiverse.com)) to empirically test the hypotheses. Thingiverse is a digital forum for the 3D printer user community to upload and freely share computer-aided design (CAD) drawings, download other contributors' digital designs, modify them, and print them. "The 3-D printing user community, for example, delivers content for Thingiverse, a community website that allows anyone to post his or her CAD designs, which other users can then download, modify and print" (de Jong and de Bruijn 2013). The Thingiverse website was established in 2008, and its growing repository is currently considered to be the "most extensive publicly available collection of 3D printable designs" (Rindfleisch 2014). Thus, Thingiverse provides a transparent system of innovation in which ideas may be readily borrowed from other consumer-creators, modified, and diffused (Kyriakou, Englehardt, and Nickerson 2012).

The 3D printing medium is a form of manufacturing that is readily accessible to individuals, relatively low in cost, and capable of producing customized objects in batches of one (Rindfleisch 2014). 3D objects can be printed out of numerous materials, including resin, thermoplastic ABS and PLA filament, ceramic, and metal (Kyriakou, Englehardt, and Nickerson 2012). 3D printing using an additive manufacturing process in which the materials are layered in a successive manner to create a physical object from a digital design (Rindfleisch 2014). The additive process is a contrast from traditional techniques such as milling or lathing, which result in discarded material. Since the additive process dramatically reduces material waste, the

incremental cost of printing 3D objects is relatively lower for individual users (Rindfleisch 2014). A more complete description of 3D printing communities, the process of 3D printing, and Thingiverse data is provided by Kyriakou, Englehardt, and Nickerson (2012) and Rindfleisch (2014).

This study utilizes a web scraping approach to gather data from publicly-available fields from the Thingiverse website in a manner that is similar to prior researchers (Galak, Small, and Stephen 2011). Web scraping was conducted by using the Linux-based Ruby programming language. The scraping program iterates over thousands of design webpages and designer webpages to extract various data metrics that measure granularity, modifiability, and designer reputation. A complete population of Thingiverse data was scraped at the end of September 2013, including the entire five-year range of designs that have been published starting from October 2008. In total, the data set includes all 51,030 published designs and information on all designers who created those designs. Table 8 displays a summary description of all variables scraped from Thingiverse.

#### **4.5.3 Dependent Variable**

The number of downloads of each product design is utilized as the dependent variable. Thingiverse tracks and displays the number of times that each digital product design is downloaded by users in the community. Downloading a digital design file is required in order to print the physical product. A download signifies that community members find value in using the product design. Thus, a higher number of downloads by users suggests a higher rate of user selection of the product design.

Other potential dependent variables were considered, such as the number of “views” for each design, the number of “likes” for each design, and the number of times that the design is “made” (printed). The number of views is problematic as a dependent variable since it does not directly indicate whether the product design is selected. In fact, it is typical for community members to view numerous different product designs prior to deciding upon a particular design to download for printing. The number of likes is interesting but seems to be a more superficial level of selection than actual downloads. Downloading is much deeper than simply “liking” something (e.g. liking a post on Facebook) or only viewing it.

The number of times that a product is made is interesting and may potentially indicate a higher degree of selection than the number of downloads. However, the number of “makes” is an optional field that is subjectively indicated by the user community. In other words, only a small fraction of the users that print a product design will take the extra step to upload a photo of their finished, printed product. Thus, the number of makes is a less reliable metric for a dependent variable, as opposed to the number of downloads and views, which are objective measures that are recorded automatically by Thingiverse. Due to these theoretical considerations, the number of downloads emerged as strongest dependent variable to measure design selection by individual users.

#### **4.5.4 Independent Variables**

*Design Granularity.* Granularity is measured in three ways. First, a continuous variable is calculated as the text count of the number of characters of printing instructions for each product design. The designer can leave specific printing instructions for the design for the purpose of offering information that aids subsequent users in printing the design. Detailed instructions are



evidence that the designer has attempted to print the digital design and is offering advice on any special circumstance that may improve the quality of the print. Thus, a greater amount of printing instructions reduces the risk that the design could potentially fail during printing. In other words, a greater amount of printing instructions indicates a lower level of granularity about the design.

Second, a continuous variable is calculated as the text count of the number of characters of description for each product design. The design description may contain specific information about the design that helps subsequent users determine whether to download the design. A more complete product description acts in a similar manner to more complete printing instructions because the amount of description may reduce the risk that the design could potentially fail during printing. Thus, more design description information indicates a lower level of granularity that is associated the design.

Third, a continuous variable is calculated as the text count of the number of characters of comments offered by the designer about the design. For each product design, community members may leave comments or ask questions about the specific design. Often these community comments are questions posed to the designer to further improve the existing design or suggest the creation of other designs that would be used with that product. The product's designer has the option to respond to the community's comments.

The number of designer comments about a design is a measure of granularity because the comments pertain to the specific design, so a user would interpret this information in the context of evaluating a design and whether to download it. The designer's comments appear with the webpage information about the product design, not with the separate webpage that contains information about its designer. If the user wishes to investigate the designer's reputation, she

much click on the designer's link to go to a separate webpage to obtain the reputation information such as the number of followers, number of things that the designer has created, and so forth, which are discussed below in the description of moderating variables. A greater amount of designer comments about a product design indicates a greater level of engagement and support for the digital product design. The designer's comments serve to lower the granularity that is associated with the design. As a result, this support from the designer gives further confidence to subsequent users of the design that the product will meet their expectations when downloaded and printed.

*Design Modifiability.* Modifiability is the ability of designs to be adapted to personal preferences for consumption. Modifying an existing design signifies an even higher degree of involvement in the creation process than downloading an unaltered design and printing it. Two variables were collected that related to modifiability. First, a binary variable labeled "customizer" was gathered that indicates that a design can be customized to user preferences with a specific customizer app. The customizer app allows the user to modify the digital design along finite parameters that are pre-defined by the designer. The user starts with the basic design and simply selects parameter choices from drop-down menus or sliding scale bars to refine the digital design prior to printing. For example, the customizer app is often employed to allow the user to change the dimensions of the digital design to meet the preferences of the individual user. Such dimensions and other option choices are limited to the choices that are established by the designer.

Second, modifiability can be assessed as whether the digital design has been "remixed." A remix is a unique modification of a previously published design. With a remix, a user starts

with an original design that was created by a designer, and then alters the actual design file via programming or CAD design software in order to create a new design. If a design has been remixed, this is direct evidence that it was originally designed with the ability to be modified by other community members. This type of modification requires more involvement and creativity from the user than simply selecting choices from a pre-defined list of parameters via the customizer app.

Since there clearly seemed to be three distinct levels of modifiability, this study constructed one ordinal variable to measure an escalating degree of design modifiability. The first level of modifiability is simply downloading an existing product design without altering it prior to print. The second level is using the customizer app to adapt the design to personal preferences within the pre-defined range of parameters made available by the designer. The third and highest level of modifiability is indicated by a remix in which a user has revised the product design file to create a new product that meets unique personal preferences.

*Community Review.* The construct of “community review” pertains to the manner in which Thingiverse users evaluate the product designs that are created and shared by designers. This construct was not specifically included in the original dissertation proposal. While there are no hypotheses that specify the direct effects of community review on product design selection, the relevance of this construct became apparent during data collection while attempting to better understand the nonmarket innovation user community. Some proposed measures for this construct are described below since they will be leveraged in a later portion of this research stream.

Three variables are utilized that relate to design evaluation to measure community review. First, the number of “likes” is indicated by community members for each product design. A like is a subjective judgment about the design. Each community member has the option to like a particular design, which denotes a compliment to the designer as well as a positive signal to other community members who may be evaluating whether to download the design. Even though the Thingiverse community is still emerging, there is already wide variance in the data for this metric. Some designs have zero likes, while others have as many as 976 likes. In this data set, the average is approximately 15 likes per design. As more consumers become engaged in 3D printing, the number of community members who evaluate designs will increase dramatically, leading to further variance for this metric.

Second, the number of “makes” for each design is collected as a measure of community review. After a user prints a product design, she has the option to indicate to the community that she has made the product. Unfortunately, a chronic problem with the “make” variable is that there is a lack of data available because most users will print a product design without returning to the design site to indicate that they have made the product. The vast majority of designs have zero community members noting that they have made the object. The maximum number of makes is 168, but the average is only 0.7 per design. The lack of activity for the “makes” measure suggests that it is not yet sufficiently developed to serve as a suitable metric.

Third, a continuous variable is calculated as the text count of the number of characters of comments offered by the community about each design. As noted above, community members may leave comments or ask questions about each specific design. These community comments may be questions and feedback to the designer to further improve the existing design or suggest the creation of other designs that would be used with that product, or the comments may be

directed to the community. These comments tend to be positive in tone and are generally intended to be helpful to other community users. For example, community members may answer each other's questions about particular designs, or they may offer compliments and ideas to aid other community members in creating further innovative product designs. In either case, active community comments suggest interest and support from other community members about a product design. A greater number of comments signals more positive feedback in the evaluation of a product design.

#### **4.5.5 Moderating Variables**

Several variables were collected in an attempt to measure the reputation of the individual designers. Most importantly, designer reputation is measured as the number of followers that each designer has garnered. Thingiverse users can publicly signal that they “follow” a particular designer, which is a very high complement that is attached to a specific designer rather than to an individual design. This is a direct measure of a designer's reputation within the user community since a designer that accumulates a higher number of followers has earned a higher level of standing within the Thingiverse community.

Additionally, a variety of other available continuous variables were gathered that are attached to the designers, such as the number of “things” that a designer has published. The number of things is the number of original designs that a designer has created and published. A higher number of things suggests a greater volume of experience with designing objects for 3D printing and may signal a higher level of expertise with 3D printing. Similarly, this study utilizes the number of makes that a designer self-reports that she has printed, the number of designs that a designer self-reports that she likes, and the number of designs that a designer self-reports that

she collects. Each of these metrics may indirectly suggest a higher level of activity and engagement by the designer with the Thingiverse community. As a result, a user that is influenced by the reputation of the designer may perceive that there is less risk of a design failing to print if the designer has accumulated more experience with designing printable objects and a greater level of engagement with the 3D printing community.

#### **4.5.6 Control Variables**

The analysis incorporates several control variables to address some of the imperfections in the secondary data. For example, time is a chief concern because new designs are constantly being uploaded to the Thingiverse website, meaning that not all designs have been afforded an equal opportunity to be evaluated by the community and to be downloaded by individual users (Rindfleisch 2014). Since designs that have been created more recently have experienced fewer occasions to be downloaded by subsequent users, this study utilizes a control variable to account for the number of days that each design has been available on Thingiverse. This variable is calculated as the number of days between the date of design publication and the date of data collection.

Further, a categorical variable is collected that is labeled “featured.” When a design is featured at Thingiverse, it is highlighted and given additional promotional coverage when a user first arrives at the Thingiverse website. The employees at Thingiverse determine which designs to feature, although it is unknown how Thingiverse decides to choose this distinction. The featured designation should naturally increase the number of times that a particular design is viewed by users. However, it remains unclear whether the featured label actually influences selection of product designs by users since this designation comes from the website administrator

rather than the user community. As a result, this distinction is included as a binary control variable in order to reduce any bias related to the featured designation.

Finally, the empirical analysis controls for the number of times that each design is viewed. There are a number of factors that could drive the number of times that a product design is viewed by the user community. The design could be a popular cultural icon such as the Star Wars Yoda character, be highly novel such as a unique Halloween mask, be highly functional such as a replacement part for a common machine, have memorable images such as a printable prosthetic hand, or be controversial such as a printable gun. Attempting to understand the antecedents of what causes a higher occurrence of design views is outside the scope of this dissertation. Nonetheless, the number of views may impact the research questions because designs with a higher number of views have more opportunities to be evaluated by the community and downloaded by individual users. Thus, the number of views is included for each design as a control variable.

#### **4.5.7 Data Collection Constraints**

Several constraints were encountered during the web scraping process that are described as follows. Initially, the dissertation proposal stated a plan to include an additional measure of granularity as a binary variable that indicated whether each design includes an actual photo of the printed product or just a digital design image. If the product image is just a CAD design image, the design may or may not be printable. For example, a designer could simply scan an existing object and upload the digital CAD image without attempting to print the design. In contrast, an actual photo of the finished, printed product is much stronger evidence that the design is printable. Unfortunately, the web scraping program was unable to collect the actual

photos of the designs because the scraping program could not accurately distinguish between photos and design drawings. In an effort to remedy this problem, an attempt was made to have the scraping program collect whether the label “thingiview” was included on the design image, because the thingiview label designates design CAD drawings instead of actual finished product photos. However, several ambiguities were encountered because some designs had multiple thingiview images while other designs did not seem to be printable objects but did not have thingiview images. Ultimately, due to the lack of web scraping accuracy of the design photos, this binary metric was excluded from further consideration because it was not reliable.

Similarly, the web scraper was unable to collect information on the “make” photos due to the same problem as noted above in the discussion of the granularity measures. When a design is designated as a “make,” the consumer sometimes uploads a photo of the item that she printed. Unfortunately, data measuring such photos were unable to be collected.

Additionally, the dissertation proposal initially stated a plan to assess whether the designer was a professional firm or anonymous individual. At the time of data collection, virtually all of the available designs appear to be published by anonymous individuals. Very few designs are yet to be published by professional firms. Further, the difference between an anonymous individual versus a professional firm was determined to be ambiguous rather than a clear distinction. For example, close scrutiny of a sample of the “professional firms” that are publishing designs revealed that the majority of them are actually small groups of individuals who share an interest in 3D printing and are recreationally attempting to offer boutique services related to 3D printing. Most of these groups of individuals do not have an established brand that would already be recognizable with an established meaning and positioning among consumers. As a result, it became problematic to create a clear system to classify designers among their



previously established brands. Due to the murkiness of this distinction in the secondary data from Thingiverse, this research project attempts to clarify the question of designer reputation as an added study that was not part of the dissertation proposal. The experimental research design is described in Study 2, which follows Study 1.

## 4.6 Results

The hypotheses are empirically tested using a moderated regression approach. Table 9 contains a summary of the results that are discussed below. Model 1 (Table 9) depicts the results for the control variables only. Model 2 tests the direct effects of design granularity on number of downloads by users in the nonmarket innovation community. The adjusted  $R^2$  value is 0.412.

Granularity has statistically significant effects at the 0.05 level as measured by the independent variables of design description ( $\beta = 1.000, p < 0.01$ ), design instructions, ( $\beta = 0.220, p < 0.01$ ), and design comments by designer ( $\beta = 1.395, p < 0.01$ ). The lower the granularity, which is measured by a higher volume of description, instructions, and comments from the designer about her design, the greater the number of downloads by users. The control variable for days is statistically significant ( $\beta = 0.567, p < 0.01$ ), as is design views ( $\beta = 0.472, p < 0.01$ ), while the featured designation is not statistically significant. Notably, the granularity coefficients for design description and design comments by designer are higher than the coefficients for the control variables of days and design views. Thus, the results suggest support for  $H_7$  that individual users are more likely to select unaltered nonmarket innovation product designs that exhibit lower design granularity.

Model 3 tests the direct effects of design modifiability on number of downloads by users in the nonmarket innovation community. The adjusted  $R^2$  value is 0.408. Modifiability has

statistically significant effects at the 0.05 level as measured by the independent variable creation degree ( $\beta = 64.868, p < 0.01$ ). The greater the degree of design modifiability, the greater the number of downloads by users. The control variable for days is statistically significant ( $\beta = 0.593, p < 0.01$ ), as is design views ( $\beta = 0.489, p < 0.01$ ), while the featured designation is not statistically significant. Again, the modifiability coefficient for design creation degree is higher than the coefficients for the control variables of days and design views. This offers support for H<sub>8</sub> that individual users are more likely to select nonmarket innovation product designs that exhibit higher design modifiability.

Model 4 investigates the direct effects of designer reputation on number of downloads by users in the nonmarket innovation community. The adjusted  $R^2$  value is 0.408. Virtually all of the independent variables utilized to measure designer reputation are not statistically significant, except for the number of designer followers ( $\beta = 0.064, p < 0.05$ ). As first glance, this outcome might suggest weak support for the notion that individual users are more likely to select nonmarket innovation product designs that are created by designers with a higher reputation. However, the coefficient for designer followers is quite low compared to the independent effects found for design granularity and design modifiability.

Subsequently, Model 5 simultaneously tests the effects of design granularity, design modifiability, and designer reputation on number of downloads. The adjusted  $R^2$  value is 0.412. The coefficients for design granularity continue to be statistically significant for design description ( $\beta = 0.983, p < 0.01$ ), design instructions, ( $\beta = 0.216, p < 0.01$ ), and design comments by designer ( $\beta = 1.380, p < 0.01$ ). Also, the coefficient for design modifiability is statistically significant for creation degree ( $\beta = 39.326, p < 0.01$ ). Meanwhile, the only independent variable for designer reputation that is statistically significant is designer followers ( $\beta = 0.076, p < 0.01$ ),

with a coefficient that is very low in comparison to the stronger effects shown by design granularity and design modifiability. Even the control variables of days ( $\beta = 0.556, p < 0.01$ ) and design views ( $\beta = 0.469, p < 0.01$ ) had higher coefficients than that of designer followers.

Next, Model 6 examines the moderating effects of designer reputation. Since the number of designer followers emerged as the only measure of designer reputation with statistically significant effects, this variable is selected as the interaction term with the measures for design granularity and design modifiability. The complete results of Model 6 are depicted in Table 9. The key finding is that the interaction terms all have coefficients that approach zero for these variables: designer followers \* design description ( $\beta = 0.003, p < 0.01$ ), designer followers \* design instructions ( $\beta = 0.002, p < 0.01$ ), designer followers \* designer comments ( $\beta = 0.001, p < 0.01$ ), and designer followers \* creation degree ( $\beta = 0.075, p < 0.05$ ). Even the most substantial interaction coefficient of design followers \* creation degree ( $\beta = 0.075, p < 0.05$ ) would be inconsequential when considered with the coefficient of creation degree ( $\beta = 32.730, p < 0.01$ ). As a result,  $H_{9a}$  and  $H_{9b}$  are rejected because designer reputation does not moderate the effects of design granularity and design modifiability on user selection of nonmarket innovation product designs.

Finally, the analysis investigate the effects of community review on the number of downloads by users in the nonmarket innovation community. These results are depicted in Table 10, Model 7. The adjusted  $R^2$  value is 0.430, which is the highest adjusted  $R^2$  value among all of the models tested from the Thingiverse secondary dataset. Community review has positive, statistically significant effects at the 0.05 level as measured by the independent variables of design likes ( $\beta = 13.409, p < 0.01$ ) and comments by the community about the design ( $\beta = 1.114, p < 0.01$ ). The remaining community review variable under consideration, design makes, was not

statistically significant at the 0.05 level. As discussed above, there may not yet be a sufficient amount of data accumulated for the “makes” variable for it to be a reliable indicator for this dataset. The most interesting finding of this model is that the effects of design “likes” on downloads is quite strong compared to most of the variables that were analyzed. Subsequently, this variable is explored further in the behavioral lab, as described below in Study 2.

## **4.7 Study 2 – Behavioral Lab Experiment Data**

### **4.7.1 Research Design Methodology Overview**

*Research Objectives.* The main purpose of the behavioral lab experiment in Study 2 is to address the limitations of the data that were web scraped for Study 1. One limitation of using the number of downloads as the dependent variable is that downloads do not equate to direct product adoption, product use, and satisfaction for all consumers. The number of downloads is a measure of product selection, so it is reasonable to assume that the consumers who download a product design intend to use it. However, the behavioral lab enables this research to more directly draw this conclusion by measuring participants’ intentions to use such products and their ultimate satisfaction with the modification process and product outcome.

A second limitation of the secondary data is that the degree of modifiability is treated as an ordinal variable with only three clear levels of modification. However, Study 2 addresses these assumptions by having participants engage in product design modification tasks and subsequently measuring their feeling that they have been involved in modifying and creating the product. This approach enables this research to test the key idea uncovered from Study 1 that an individual’s escalating involvement in modifying a nonmarket innovation product design to meet her preferences increases her likelihood of using the product. Again, the behavioral lab allows

this research to directly link this involvement in creation to the individual's satisfaction with the modification process and product outcome.

Finally, a complimentary objective of the behavioral lab experiment is to explore the role of the community review mechanism and how it influences individuals' decisions to select a product design created via nonmarket innovation. As mentioned in Study 1, the community review mechanism emerged as an important factor that influences individuals' selection decisions. As a result, the experiment includes a manipulation that enables the isolation of this effect by assigning separate groups to high and low positive community reviews. The details of the experimental procedures are described in more depth in the following section.

*Experiment Overview.* This study employs cell phone cases as the product category of focus for several reasons. First, cell phone cases are a familiar product that almost all of the participants already use or have considered using in their daily lives. There is no need to explain what the product is or what it is used for since this is already common knowledge among the subject population. Second, cell phone cases are one of the most popular items available for download at Thingiverse, so using this product mimics natural preferences of users in 3D printing communities. As a result, this study can avoid speculating about the usage patterns of this product design by actual users within the nonmarket innovation community since these users are already creating hundreds of cell phone case designs on their own. In other words, this approach should increase the external validity of the study.

Third, a cell phone case customizer app already exists at Thingiverse that was leveraged to allow subjects to make selections to modify a basic cell phone case digital design for the purpose of meeting individual consumption preferences. Again, this provides further

concreteness to the study and avoids constructing an unrealistic environment. Fourth, cell phone cases are relatively simple products that are easy to 3D print. This simplicity enables the study to give the participants a future opportunity to actually engage in printing their unique cell phone case designs in an efficient manner at the 3D printing lab that is located in the University of Illinois College of Business. By having participants print their actual product designs, this research is able to assess the participants' post-print satisfaction with the creative design process, their satisfaction with the tangible printing process, and their satisfaction with the resulting physical product. The participant printing activities are the topic of Study 3, which is described in a subsequent section of this chapter.

An appealing feature of using the experimental approach to explore nonmarket innovation is that it naturally accounts for many of the factors that had to be included as control variables with the secondary data. For example, the experiment does not have any noise with respect to the number of days that a product design might be visible at a public website. Moreover, the product design is not featured, and there is no accumulation of design views that might influence users' decisions to select the product design. Also, the experiment does not have any differences with respect to design granularity, such as the design description, printing instructions, or comments from the designer. As a result, the experiment should provide a stricter test of the hypotheses.

#### **4.7.2 Data Collection**

In total, 198 students participated in this study. All behavioral lab data were collected within a one week time frame. Students signed up to participate in advance of the start of any of the sessions being conducted. This approach minimized threats of self-selection bias, as it

ensured that the purpose of the study did not spread via word-of-mouth to other students prior to the signup period. While designing the research plan, a concern arose that if participants knew that the study would include the opportunity to obtain a free 3D printed cell phone case, some students might be motivated to sign up just because they were interested in 3D printing or wanted a free cell phone case. The approach taken for this study helped to prevent this threat to internal validity by ensuring the acquisition of an unbiased sample.

For the very first question of the study, prior to exposure to any product stimuli, participants are asked to indicate the type of cell phone that they currently own. In aggregate, 72.7% of participants indicated that they currently own an Apple iPhone. A binary control variable will be used to account for whether the subject owns an Apple iPhone or any other brand of phone. This variable will help control for any ex-ante biases that participants may have, either positively or negatively, about the Apple brand.

Next, the experiment had all participants read a brief standardized description of 3D printing technology and a standardized description about the concept of 3D printing a cell phone case. In addition to measuring the effects of design modifiability on individuals' selection decisions, Study 2 seeks to further explore the nonmarket innovation mechanism of community review and how it affects individuals' selection decisions. The participants were randomly assigned to one of two groups (high positive community review versus low positive community review). Participants in both groups were exposed to identical product stimuli prior to the manipulation of low or high community review in which they were told that a 3D printable cell phone case had been designed by an anonymous individual who had freely posted the design for other community members to use. This approach mimics the realistic sequence of how 3D printing users actually encounter information at Thingiverse, where they see a digital image of

the basic cell phone case design and community review information prior to being able to customize and/or download the product design for printing. Questions were included that immediately follow these brief product stimuli descriptions, but appear before the group-specific community review manipulation, that ask the subjects to confirm their basic understanding of 3D printing and 3D printed cell phone cases. There were four participants that indicated that they did not understand 3D printing or what the experiment meant by “3D printed cell phone case,” so those four observations were omitted from data analysis. This yielded a usable sample of 194 observations.

Subsequently, participants received their group-specific community review treatment. Both groups were given identical information about how 3D product designs are shared freely by designers and that subsequent users have an option to indicate whether they “like” that particular design. Further, both groups were told that the “like” option is a voluntary public feedback process that provides a complement to the designer and that users can view how many likes a design has accumulated. The high positive review group was told that 500 out of 10,000 anonymous viewers “like” the basic cell phone case design, whereas the low positive review group was told that 5 out of 10,000 anonymous viewers “like” the design. This approach enables a stricter test of whether the community review mechanism influences selection behavior than the secondary data because it enables comparison of the results of the two treatment groups while minimizing other factors that could affect the outcomes.

After the group-specific treatment, all participants followed the same prompts that gave them the opportunity to modify the basic cell phone case design. The modification exercise included five different parameters that were available for customization (pattern shape, pattern thickness, pattern radius size, frame thickness, and color). Each parameter provided the option to



make one selection from among two to five possible choices. Also, each parameter provided the option to make no selection (no preference) rather than forcing the participants to artificially choose to customize the design. As a result, this method allows for a stricter test of the degree of creation variable than was available with the secondary data because the participants were allowed the freedom to make numerous modifications. In contrast, the secondary data was restricted to the identification of three ordinal categories rather than delving into how many modifications were made by users to each individual design. Again, the approach taken for the experiment mimics how users experience the process of customizing basic designs in a nonmarket innovation community.

Next, participants responded to a series of questions to assess their degree of satisfaction with the product design modification process and the extent to which they felt like they were involved in creating their cell phone case design. Also, participants answered questions pertaining to their purchase intention of their customized cell phone case if it were 3D printed. They were asked how much they would be willing to pay to receive a 3D printed cell phone case that they had customized as in the modification exercise, and the extent to which they would pay more or less for their customized printed cell phone case compared to purchasing an off-the-shelf case designed by a professional firm. Further, participants were asked their likelihood of using the cell phone case that they had designed. This approach helps to form a more direct link between individual product design modification and expected product use than was established with the secondary data measure of downloads.

At this point, all participants were told that the customizable cell phone case design was created by Apple. The participants then completed a survey questionnaire pertaining to how the brand source affects their purchase intention for the cell phone case that they have designed.

Further, the participants answered questions regarding how their awareness that Apple was creating such 3D printable, customizable designs might affect their perception of Apple with respect to its brand, quality, and innovativeness.

The experiment finished with asking participants to self-report their degree of prior experience with 3D printing, Thingiverse, CAD software, the UIUC Maker Lab, and new product development, as well as demographic questions. The demographic statistics of the participants are as follows. Participants were 40.7% male, and 59.3% female. They were all undergraduate students, with most being sophomores (54.6%) and juniors (35.1%). About two thirds (67.5%) indicated an enrollment status of domestic while the remaining one third (32.5%) indicated an enrollment status of international. The participants were asked to type their primary preferred written language, for which the most common response was English (78.9%). The second most common response (16.0%) was Chinese and/or Mandarin. They were predominately affiliated with the College of Business (79.4%), with other participants from the College of Liberal Arts and Sciences (5.7%), the College of Engineering (5.1%), the College of Media (3.1%), and the College of Agriculture, Consumer, and Environmental Sciences (6.7%). Participants were asked to rate their prior experience with various aspects of this study on a seven-point scale, where the endpoint 1 was labeled as “no experience,” and the endpoint 7 was labeled as “extensive experience.” The respondents indicated a very low level of prior experience with the following average values for 3D printing (1.7), Thingiverse (1.2), CAD software (1.7), the University of Illinois Maker Lab (1.5), and new product development (2.0).

At the conclusion of the behavioral lab study, the participants were given the opportunity to print their unique cell phone case designs at the University of Illinois Maker Lab. Participants were informed that they could print their cell phone cases free of charge as part of this research,

but that they were not required to print their cases in order to receive course credit. Nonetheless, the response was positive, as 115 participants (59.3%) indicated a preference to visit the Maker Lab in a subsequent week to learn to 3D print their cases, which they were advised would take about an hour to an hour and a half of their time. Additionally, 49 participants (25.3%) did not want to learn to 3D print their design, but still chose the option to have the Maker Lab print their cases for them, which they would pick up when ready during a subsequent week. The balance of 30 participants (15.4%) chose not to receive their 3D printed cell phone cases. The portion of this research that pertains to data collection via use of the Illinois Maker Lab is described in the following section.

## **4.8 Study 3 – Maker Lab 3D Printing and Survey Data**

### **4.8.1 Research Design Methodology Overview**

Immediately after the behavioral lab study was complete, participants who chose to receive their 3D printed cell phone cases (either by learning to print it themselves or having the Maker Lab print it for them) were given a form with directions to the Maker Lab. Each participant was given a randomly generated, unique numeric code during the experiment, which the participants were instructed to copy onto their Maker Lab directions form. Use of the unique numeric code enabled this study to match up each participant's unique cell phone case design (completed in the behavioral lab) with the corresponding case to be 3D printed at the Maker Lab. Participants were instructed to retain this form and bring it to the Maker Lab to ensure that they obtained their unique case designs. Finally, participants were informed that they would be requested to answer a brief survey at the Maker Lab to provide feedback on their satisfaction upon receiving their final printed product.

Prior to printing the cell phone cases, design files must be created that are compatible with the 3D printers. For this study, the customization choices that the participants completed in the behavioral lab were converted to stereolithography (stl) design files using a Thingiverse iPhone case customizer app. The stl files were then exported as x3g print files using MakerBot MakerWare software. MakerWare is a free software tool that is commonly used to process digital designs into files that are suitable for 3D printing with MakerBot “Replicator 2” desktop 3D printers. MakerWare was chosen for file conversion because the Illinois Maker Lab is equipped with twelve MakerBot Replicator 2 desktop 3D printers.

Due to the high response rate of participants who elected to learn to print their designs at the Maker Lab (59.3%), a scheduling system was created whereby participants signed up for a time slot for printing. Each time slot was limited to eight participants in order to avoid a situation in which more participants would want to print at a given time than the Maker Lab has resources to accommodate. Thus, the purpose of the scheduling system was to prevent the possibility of participants having to wait in line to print, or having to return to the Maker Lab on multiple occurrences in order to find an open time with printers available. Participants who chose this option met with a Maker Lab technician to learn to print their cases. Participants who chose to have the Maker Lab print their cases in advance were notified when the cases were ready for pick up. As a result, there was a time lag of 2 – 5 weeks between the behavioral lab portion of the research (Study 2) and the subsequent Maker Lab portion of the research (Study 3).

#### **4.8.2 Data Collection**

Participants were asked to complete a brief post-print satisfaction survey using Qualtrics at the Maker Lab immediately after receiving their cell phone cases. The survey began by asking

whether the participant had printed her cell phone case or if the Maker Lab had printed the case, which she had picked up. Then, questions were asked about the degree to which the participant felt involved in creating the case, the likelihood that she would buy the case if it were available for purchase, and the likelihood that she would design products again for the purpose of 3D printing. When possible, identical language was replicated for the Maker Lab post-print survey items as was used during the behavioral lab portion of the research.

Next, questions were asked about the participant's satisfaction with the product design modification process and the 3D printing process. An open-ended text box question allowed participants to indicate why they were satisfied or dissatisfied with the final physical product. Also, two control variable questions were included to assess the extent to which color choice constraints and printing quality imperfections may have influenced participants' post-print satisfaction. The survey concluded by asking participants to enter their unique numeric code.

Unfortunately, the conversion rate of participants who have gone to the Maker Lab to either pick up their pre-printed cases or learn to print their cases with the help of a Maker Lab technician has been lower than hoped. Initially, less than half of the behavioral lab participants who indicated that they wanted to 3D print their cases at the Maker Lab actually signed up for a time slot. Additional time slots were opened on a Saturday that seemed to be particularly popular as most of the original time slots filled quickly. Of those participants that signed up for any of the available time slots, only about half actually went to the Maker Lab to print their cases. Similarly, less than half of the participants who chose to have the Maker Lab print their cases have actually picked up their finished cases. Separate reminder emails were sent to participants to ask them to pick up their pre-printed cases anytime during normal Maker Lab operating hours, or to attend the Maker Lab to learn to print their cases with the help of a technician anytime

during normal Maker Lab operating hours. Despite these efforts, only 36 cases were converted prior to spring break. As a result, the data collection for Study 3 continued during April and May but has only yielded a few more participants.

## **4.9 Implications**

### **4.9.1 Theoretical and Empirical Contributions**

This paper has numerous opportunities for potential theoretical contributions. First, this essay submits the relevance of social production and, especially, independent nonmarket production (Benkler 2006) to the marketing domain. Independent nonmarket production is understudied compared to the more well-known peer production (e.g. open source software). While OSS has been studied in various management and information science contexts, independent nonmarket production has high relevance for marketing because it bypasses the traditional market exchange mechanism utilized by manufacturers, service providers, retailers, and consumers. Further, this nonmarket approach gives rise to a new type of consumer that has both the ability and the willingness to innovate to meet individual consumption needs. The growing number of consumer-creators and their process of selecting and consuming products is a relatively new area of inquiry within the marketing domain.

Second, this essay conceptualizes nonmarket innovation to encompass the system of community selection as well as independent nonmarket production. This essay makes a theoretical contribution by expanding the conceptual framework of social production to add the dimension of community selection as a system to evaluate the success of new products that are developed using independent nonmarket production. Community selection is highly relevant to

the marketing literature because it occurs in the absence of market transactions or firm governance, yet it influences how users evaluate and choose designs for consumption.

Third, a notable distinction between this research and Benkler's (2006) view of social production and much of the research on 3D printing (e.g. de Jong and de Bruijn 2013) is that those works take the perspective of the designer to theorize the likelihood of new product success. Instead, this chapter takes the perspective of the consumer, reflected as the community that selects the product designs for downloading and printing, to determine the success of new products that are developed with independent nonmarket production. This is a novel approach, as the majority of prior research on social production attempts to unpack why individuals decide to contribute to social production. The phenomenon of community selection is relatively understudied. As a result, this essay makes a contribution by operationalizing and empirically testing social production as it pertains to the community selection process.

#### **4.9.2 Managerial Contributions**

The implications of this research are relevant for firms for several reasons. First, the results are insightful for managers that seek to understand nonmarket innovation, the emerging behavior of consumer-creators, 3D printing user communities, community selection mechanisms, and how these forces will disrupt their existing markets. In particular, firms are interested in understanding how to predict which consumer-creator innovations will be successful so that they can be proactive to integrate those ideas in their own NPD activities. Consumer-creators that use 3D printing technology are cutting edge users in an emerging space that is expected to grow rapidly. Understanding the behavior of lead users offers insight into the future consumption behavior of larger markets when early adopters cause an acceleration of product diffusion. A

firm's ability to capture the early adopter market is often a key time period for making profits in a product's life cycle. Therefore, predicting the behavior of early adopters, by understanding initial user behavior, is of critical interest to firms.

Second, this research is insightful for companies that wish to take consumer-created designs and subsequently modify them, improve their quality, and sell them to a wider scope of passive consumers through traditional market transactions. Such firms may choose to build upon these freely-available ideas to manufacture and sell the next generation of products that are of higher quality and/or lower cost than those offerings generated through independent nonmarket production (de Jong and de Bruijn 2013). For example, the number of user-designed, 3D printable cases for iPhones is growing exponentially, to the point that Apple has taken notice and acquired some of the more popular consumer-created designs to re-sell at its retail outlets. In particular, the iPhone case is an interesting example because it shows the relevance of this research topic based upon the behavior of a market leading firm with a globally-recognized brand. Moreover, this example validates the reality of potential concerns for competition, opportunity, profit, and the entry of these nonmarket innovations into mainstream traditional retail markets.

Paradoxically, this illustration shows that nonmarket innovation not only avoids the familiar transaction-based marketplace, but essentially reverses the traditional market exchange process. Historically, firms have tended to undervalue consumer-created new products as a source of innovations that they can adopt and modify through internal NPD efforts in order to improve their own product offering (von Hippel, de Jong, and Flowers 2012). Yet nonmarket innovation offers an opportunity for proactive firms to obtain and modify consumer-created new



products, and to subsequently improve and resell the products to other consumers (de Jong and de Bruijn 2013).

Third, there is an opportunity for firms to participate in and, potentially, influence 3D printing communities. In contrast, other forms of social production typically have a project maintainer who acts as a community moderator in a role that is similar to OSS projects that have a lead developer or project manager. Such maintainers are fiercely skeptical of intrusion by incumbent firms because they do not want the influence of a profit-motivated organization to discourage the ongoing contributions from individual users that are necessary to enrich and sustain the collective development effort (Hoegg, Martignoni, Meckel, and Stanoevska-Slabeva 2006). Yet with nonmarket innovation, firms are permitted to participate by contributing their own finished designs. There is a need for research that investigates when, where, and how firms may gain access to closed customer value spheres, and how firms can interact with customers to support customer value creation spheres (Grönroos and Voima 2013).

In other words, professional design firms and established incumbent brands are beginning to appear in nonmarket innovation communities because they are not excluded from providing their own designs. Since each design is essentially a stand-alone, finished product when it is published, there is no threat that an incumbent firm can adversely modify the existing content that is shared by individual consumer-creators. Still, the community retains the option to ignore the influence of professional firms by choosing not to download or modify the firms' designs. Nonetheless, those designs can remain in the nonmarket innovation space without disrupting the efforts of individuals who continue to create, share, and consume their independently created product designs. Therefore, the freely available posting of innovative ideas presents an opportunity for forward-looking firms to understand consumer-creator community selection

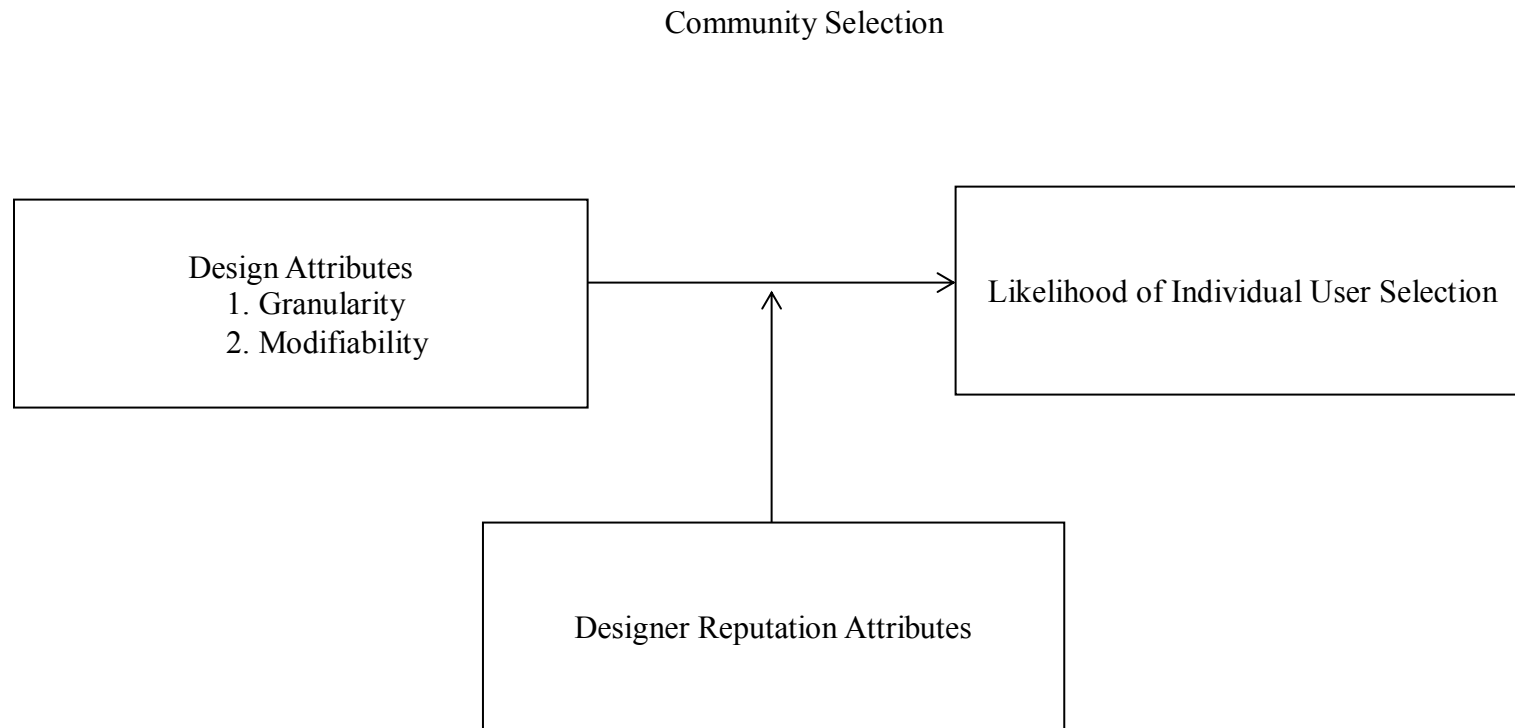
mechanisms, adopt their novel ideas, and potentially influence future products that may be selected by consumers.

#### 4.10 Tables and Figures



















**Table 6: A Simplified Comparison of Transaction Costs and Social Production**

	<b>Transaction Costs</b>		<b>Social Production</b>	
Production Choices	Hierarchy-Based	Market-Based	Peer, Community-Based	Independent Nonmarket
Transactions	Intrafirm	Market	Intracommunity	Nonmarket
Governance	Firm-Organized	Interorganizational	Loosely Based on Social Norms	None
Exchange Concerns	Opportunism, Asset Specificity	Behavioral Uncertainty, Environmental Uncertainty	Appropriation by Profit-Seeking Firms	None
Production Mechanism	Hierarchical Governance	Interganizational Governance, Contracts	Modifiability, Granularity	Modifiability, Granularity
Task Mechanism	Managerial Supervision	Monitoring, Contract Enforcement	Voluntary Self-Selection	Voluntary Self-Selection
Motivation	Primarily Extrinsic, Cooperation	Primarily Extrinsic, Competition	Primarily Intrinsic, Cooperation	Primarily Intrinsic
Property Rights of Innovation	Controlled Access	Controlled Access	Freely Disclosed	Freely Disclosed
Production and Consumption	Separate	Separate	Separate	Simultaneous
Initial Consumers of Innovation	Macro	Macro	Macro	Micro
Examples	Producer-Innovation	Partitioning and Outsourcing NPD Tasks	Open Source Software, Wikipedia	Lead User Innovation, 3D Printing

**Figure 2: Conceptual Framework Overview**



**Table 7: Hypotheses Testing**

<b>Hypotheses</b>	<b>Secondary Data</b>	<b>Behavioral Lab</b>	<b>Maker Lab</b>
H <sub>7</sub> : Lower design granularity leads to a higher likelihood of individual user selection			
H <sub>8</sub> : Higher design modifiability leads to higher likelihood of individual user selection			
H <sub>9</sub> : Designer reputation moderates likelihood of individual user selection			
Future H <sub>10</sub> : Community review moderates likelihood of individual user selection			
Future H <sub>11</sub> : Firm participation in nonmarket innovation community leads to increase in firm reputation among community members			
Future H <sub>12</sub> : Higher modification of design leads to higher feeling of creation			
Future H <sub>13</sub> : Higher feeling of creation from design modification leads to higher degree of product satisfaction			
Future H <sub>14</sub> : Higher feeling of creation leads to higher likelihood of 3D printing			
Future H <sub>15</sub> : Higher feeling of creation leads to higher likelihood of product use			
Future H <sub>16</sub> : 3D printing design leads to higher feeling of creation as compared to feeling of creation from design modification			
Future H <sub>17</sub> : Higher feeling of creation from 3D printing leads to higher degree of product satisfaction as compared to feeling of creation from design modification			
Future H <sub>18</sub> : 3D printing design leads to a higher preference for making products instead of buying			

**Table 8: Secondary Data Collection**

<b>Variable Name</b>	<b>Variable Type</b>	<b>Description</b>
Design Downloads	Dependent variable	Number of times design has been downloaded
Design Views	Control variable	Number of times design has been viewed
Design Featured	Control variable	Binary variable
Days	Control variable	Calculated based upon design published date, accounts for time each design is available
Design Description	Independent variable – granularity	Text count of characters of product design description
Design Instructions	Independent variable – granularity	Text count of characters of product printing instructions
Design Comments by Designer	Independent variable – granularity	Text count of characters of designer comments
Creation Degree	Independent variable – modifiability	Ordinal ranking of having been remixed (highest), using customizer (middle) or unaltered (lowest)
Designer Followers	Moderator – designer reputation	Number of times community assigns designer this judgment
Designer Things	Moderator – designer reputation	Number of designs published by a designer
Designer Makes	Moderator – designer reputation	Number of designs printed by a designer
Designer Collects	Moderator – designer reputation	Number of designs that a designer has bookmarked for collections
Design Likes	Independent variable – community review	Number of times community assigns a design this judgment
Design Makes	Independent variable – community review	Number of users that indicate they have printed a design
Design Comments by Community	Independent variable – community review	Text count of characters of community comments
Design Photo	Omitted, unable to scrape	Photos or CAD images of product designs
Like Photos	Omitted, unable to scrape	Photos of community members that like a design
Make Photos	Omitted, unable to scrape	Photos of printed designs
Designer Photos	Omitted, unable to scrape	Photos of designer
Professional Designer	Omitted, unable to scrape	Binary classification: professional designer or anonymous individual designer

**Table 8 (cont.)**

Note: The term “number” in the variable description field of the data plan table indicates that the variable is already available as quantified data at the Thingiverse website. In contrast, the term “count” indicates that the variable must be constructed by the web scraping program from qualitative text data that is available at the Thingiverse website.

**Table 9**

DV: Downloads		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6 (FINAL)
Variable Type	Variable Name	Control Var. Only	Granularity	Modifiability	Designer Reputation	All Indepen. Variables	Reputation Moderates
Intercept	Constant	-258.314***	-308.373***	-331.185***	-254.474***	-342.535***	-324.791***
Control Variable	Days	0.603***	0.567***	0.593***	0.597***	0.556***	0.568***
Control Variable	Featured (binary)	5.927	-40.272	-2.440	1.530	-47.949	-52.215*
Control Variable	Design Views	0.493***	0.472***	0.489***	0.492***	0.469***	0.463***
Granularity IV	Design Description		1.000***			0.983***	0.842***
Granularity IV	Design Instructions		0.220***			0.216***	0.119
Granularity IV	Designer Comments		1.395***			1.380***	1.234***
Modifiability	Creation Degree (ordinal)			64.868***		39.326***	32.730***
Designer Rep. IV	Designer Followers				0.064**	0.076**	-0.414***
Designer Rep. IV	Designer Things				0.134	0.099	
Designer Rep. IV	Designer Likes				0.009	-0.008	
Designer Rep. IV	Designer Makes				-0.322	-0.400	
Designer Rep. IV	Designer Collects				-2.898	-4.342*	
Reputation Moderator	Followers * Design Description						0.003***
Reputation Moderator	Followers * Design Instructions						0.002***
Reputation Moderator	Followers * Designer Comments						0.001***
Reputation Moderator	Followers * Creation Degree						0.075**
Adjusted R <sup>2</sup>		0.407	0.412	0.408	0.408	0.412	0.414

Coefficients: \* $p < 0.10$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.01$

All variables are continuous unless noted otherwise.



**Table 10**

DV: Downloads		<b>Model 7</b>
Variable Type	Variable Name	<b>Community Review</b>
Intercept	Constant	-278.469***
Control Variable	Days	0.549***
Control Variable	Featured (binary)	-356.411***
Control Variable	Design Views	0.353***
Community Review IV	Design Likes	13.409***
Community Review IV	Design Makes	-2.885
Community Review IV	Community Comments	1.114***
Adjusted R <sup>2</sup>		0.430

Coefficients: \* $p < 0.10$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.01$

All variables are continuous unless noted otherwise.

## **Chapter 5**

### **Conclusions**

#### **5.1 Summary**

This dissertation integrates disparate definitions of open innovation in order to classify different approaches to open innovation along two key dimensions. As discussed in chapter 2, the first dimension is based upon the initial organizer of the open innovation new product development (NPD) activities. In many cases, the activities are organized by a professional firm that orchestrates its NPD efforts (e.g. crowdsourcing) in conjunction with external individuals and other organizations. However, there is an increasing occurrence of individuals who initiate and organize the NPD activities in collaboration with other individuals. Such individuals create new products for their own benefit (e.g. lead users) and for the benefit of others (e.g. open source software).

The second dimension is based upon the intended consumer of the new products that are created via open innovation activities. A new product that is created from open innovation can be one product that is intended for use by a large number of individuals, or numerous products that are uniquely customized by individual consumers. These two dimensions enable a deeper understanding of the types of open innovation and how they are related to each other. Additionally, the dimensions provide a unique perspective for this dissertation to investigate open innovation from both the supply-side, in terms of the firms and individuals who collaborate to create new products, as well as from the demand-side, in terms of the consumers who use the new products that are created via open innovation.

More specifically, chapter 3 examines a supply-side form of open innovation that is termed “open contribution” in which a firm allows external organizations and individuals to be

actively engaged in its development of new products. While the firm permits external contributions to its NPD process, it retains internal control over the resulting innovation output. This chapter attempts to increase our understanding of the organizational mechanisms that are needed to appropriate the external knowledge that is available to multiple firms. The study develops original measures of multiple constructs to empirically reveal that the ability to predict new product outcomes is substantially improved with the addition of the adaptive marketing capabilities of vigilant market learning, adaptive market experimentation, and open marketing. In particular, adaptive market experimentation capability and open marketing capability act as the driving mechanisms to aid firms in achieving successful new product outcomes. Without these capabilities, firms that focus on open contribution may search their environment effectively yet fail to leverage the external knowledge to create and commercialize innovations. As a result, adaptive marketing capabilities emerge as internal, dynamic firm mechanisms that are necessary for evaluating the external knowledge and converting it into innovations.

In contrast, chapter 4 explores a completely different form of open innovation in which individuals independently invent new products and build on other individuals' creative ideas without any guidance or oversight from firms. This approach to open innovation is termed "nonmarket innovation" because it avoids firm-led marketplace exchanges. This chapter focuses on the factors that motivate individual consumers to select new products that are created via nonmarket innovation. The research expands theoretical views from the social production literature to explicate the concepts of product design modifiability and product design granularity, and the process of community selection, which influence individuals' decisions to use these new products. The community selection process evaluates both the product designs and the reputations of individual designers that share their original product designs. The designer's

reputation is an indicator of standing within the community that spills over onto consumers' expectations about the quality of the product designs. This research relies upon a rigorous multi-method approach that includes secondary data and behavioral lab data to test hypotheses in the budding nonmarket innovation context of three-dimensional (3D) printing communities. In particular, the results suggest that a greater degree of product design modifiability can positively influence individuals' decisions to use new products that are created through nonmarket innovation.

By investigating both the supply-side and demand-side aspects of open innovation, this dissertation accomplishes several objectives. Theoretically, this dissertation extends emerging conceptual perspectives to the open innovation literature because this continues to be an emerging area that is not wholly explained by a single existing theory. Chapter 3 conceptually delineates open contribution as a specific form of firm-led open innovation. Further, this chapter introduces the marketing capabilities literature (Morgan and Slotegraaf 2012) into the open innovation domain by explaining how specific adaptive marketing capabilities (Day 2011) are important mechanisms that firms leverage to create and commercialize innovations from the external collaboration that is encouraged through open contribution. Additionally, this chapter builds upon the emerging view of adaptive marketing capabilities to show how these capabilities enable firms to accomplish specific objectives from open contribution. This chapter asserts that marketing capabilities take an elevated role in implementing open contribution to help firms obtain favorable new product outcomes.

Chapter 4 contributes to the development of theory in the open innovation domain by drawing upon the emerging views of social production (Benkler 2006). The social production perspective offers insight into phenomena in which individuals innovate without relying on

professional firms to manage the innovation process and without using traditional marketplace transactions to exchange the resulting new products. Social production relies, in part, on the ability of products to be modified by subsequent innovators. This chapter reveals that the social production concept of modification also influences individuals' decisions to use new products that are created through nonmarket innovation.

Empirically, this dissertation seeks to make contributions to open innovation through the measurement of several emerging constructs. Chapter 3 develops original measurement scales to be among the first to operationalize open contribution and the adaptive marketing capabilities of vigilant market learning, adaptive market experimentation, and open marketing. This chapter empirically tests these constructs and links them to specific new product performance outcomes, which is an ongoing need in the mounting literature on open innovation. Chapter 4 operationalizes several incipient ideas from social production, including granularity, modifiability, and community selection. This chapter uniquely tests these measures with secondary data, behavioral lab data, and data collected by having participants engage in the 3D printing of their customized products at the University of Illinois Maker Lab.

Substantively, this dissertation offers numerous insights to practitioners of open innovation. While the benefits of firm-led open innovation paradigms have been touted for over a decade (e.g., Chesbrough 2003), managers continue to seek guidance on more specific tactics that they should pursue in order to utilize the external knowledge that is increasingly available to their NPD efforts. This dissertation's research on adaptive marketing capabilities identifies the specific capabilities of adaptive market experimentation and open marketing that firms can cultivate and leverage to obtain favorable outcomes from open contribution.

Meanwhile, nonmarket innovation communities are new phenomena that are not well-understood and have been greeted with apprehension by many firms. Some incumbents view nonmarket innovation as a hazard that possesses the potential to infringe upon their proprietary product designs (N.V. 2012), and erode the market share that they have developed and protected through years of careful marketing and management effort (Baldwin and von Hippel 2011; de Jong and de Bruijn 2013). This initial reaction is expected given that nonmarket innovation communities are becoming sufficiently proficient at new product design that they are able to offer products that compete with and displace incumbent firm-supplied products (de Jong and de Bruijn 2013; DHL Supply Chain 2013).

While not all firms are threatened by nonmarket innovation, few firms are actively participating in nonmarket innovation activities. Yet these communities of individual innovators are cutting edge developers of emerging innovation processes, and they hold much knowledge that firms can learn from (de Jong and de Bruijn 2013). This dissertation offers exploratory insight into the incipient area of nonmarket innovation and how product design granularity, product design modifiability, and designer reputation can affect individuals' decisions to use products that are created without the oversight of firms.

In summary, this dissertation offers an integrative conceptual framework (i.e., chapter 2) and research studies (i.e., chapter 3 and chapter 4) to provide theoretical and empirical explanations for important mechanisms that enable new product outcomes from different supply-side and demand-side approaches to open innovation. It is notable that these mechanisms have received limited discussion in the extant literature on open innovation, which further enhances the contributions of this dissertation. This research investigates each mechanism in depth by utilizing a multi-method approach that includes qualitative interviews, a primary survey of

marketing and R&D executives, web scraping of secondary data, and behavioral lab experiments. Additionally, this research reveals opportunities for further research to contribute to the marketing literature and innovation management literature. A few of these potential opportunities are discussed below.

## **5.2 Future Research**

This section briefly describes my plans for the three major papers that will be carved out of this dissertation for potential publication, as well my plans for future research that has been spawned by this dissertation. First, the literature review, conceptual framework (Figure 1), and typology of open innovation can become a conceptual paper. This will require adding research propositions, especially with respect to future research to be conducted in nonmarket innovation. Second, the plan for the adaptive marketing capabilities area emphasizes publishing the existing research in a high quality journal. The empirical section needs to be bolstered through an additional study so that the theoretical contributions become clearer.

Third, the plan for the nonmarket innovation area emphasizes conducting additional experiments and surveys in order to drill deeper into the mechanisms that drive these emerging phenomena. Behavioral lab data can provide insight into the sentiments of individual consumer-creators who are actively engaged in nonmarket innovation communities. Such data have the potential to address some of the limitations of the secondary data, which offer less information about the mechanisms that motivate individuals to participate in nonmarket innovation. Further, experiments and surveys would help to reveal individuals' ultimate satisfaction with the tangible product outcomes.

### **5.2.1 Adaptive Marketing Capabilities**

The chapter could become an improved, publishable paper through greater focus by taking one of three possible approaches. First, the analysis could be adjusted to test for the competing effects of market orientation versus adaptive marketing capabilities. This approach would investigate whether adaptive marketing capabilities have a stronger effect than market orientation on innovation outcomes in the context of open contribution. The original survey that was developed to support chapter 3 also collected some data on market orientation. However, the empirical evidence would be stronger with an additional study that includes a more comprehensive measure of market orientation to demonstrate a clearer distinction between market orientation and adaptive marketing capabilities.

Second, an additional data collection could be completed to show how adaptive marketing capabilities are different from marketing capabilities and how they have different effects on new product outcomes. While there are theoretical distinctions between these two perspectives (Day 2011), the three adaptive marketing capabilities have not been empirically tested to illustrate the measurable nuances of how these dynamic capabilities differ from the traditional view of marketing capabilities. Further, each capability's effect could be tested as a possible moderator that increases the effect of open contribution on innovation outcomes. This approach would require a second data collection to be conducted with extensive measures of marketing capabilities.

Third, a more comprehensive effort could be pursued to distinguish how the three adaptive marketing capabilities are distinct from each other (i.e., vigilant market learning, adaptive market orientation, and open marketing). This method would enable the further testing of the direct effect of each capability on innovation outcomes. In particular, this approach would



directly answer any methodological questions pertaining to discriminant validity among the three adaptive marketing capabilities. To show these differences, this approach would benefit from an additional data collection from a different set of respondents in order to improve the empirical robustness of the findings.

### **5.2.2 Nonmarket Innovation**

There are numerous opportunities to conduct additional research in the domain of nonmarket innovation. The data collected in Study 2 and Study 3 of chapter 4 will enable deeper investigation of the community review process, the individual propensity for making a product instead of buying one, the effect of modifying a digital design on product satisfaction and use, and the effect of a firm's participation in nonmarket innovation on its reputation. Several future hypotheses are summarized in Table 7, and the potential research ideas are further described as follows.

With respect to the community review process, experiments can examine how the community review process moderates the effect of product design attributes on the likelihood of individual users' selection of product designs. The behavioral lab data allow for the isolation of high (low) levels of community review that are shown to participants in order to examine how this review increases (decreases) their subsequent product design modification and print choices. This approach has implications for aiding the development of theory to understand how the community review process affects subsequent individuals' product adoption behavior. Additionally, there would be managerial implications to aid firms in understanding how the community review process affects the consumer selection of their designs that they may provide in nonmarket innovation communities.

With respect to an organization's reputation, the data collected in the behavioral lab also allow for the exploration of questions for how a professional firm's participation in nonmarket innovation communities affects the community's perception of the firm's overall reputation. Many firms are reluctant to participate in nonmarket innovation because they are unable to control the intellectual property of their designs, manage the potential user modification to their designs, and control of the production process. Further, many such firms are unable to envision monetary transactions with nonmarket innovation participants. The lack of apparent, immediate transactions causes them to doubt that there is a profitable incentive for participating in nonmarket innovation communities.

However, consumers may be more loyal to firms that offer proprietary designs in nonmarket innovation communities. Certainly, the current state of 3D printing technology limits the range of products that can be printed. If an individual has a positive encounter with a firm in a nonmarket innovation community, the individual may be more inclined to purchase goods and services from that firm as a result of this interaction. Thus, it seems plausible that firms could engage in nonmarket innovation to strengthen their own brand awareness and loyalty with the goal of inducing future purchases from consumers. Whether organizations' participation in nonmarket innovation would ultimately increase their profitability or detract from sales of existing products, which would erode profits, is an empirical question that can be examined with data collected in the behavioral lab.

Another feature of using the behavioral lab to advance research on nonmarket innovation is to examine how individuals' modification of product designs increases their sentiment of making a product (compared to buying a product). The secondary data that were collected via web scraping do not directly measure the degree to which participants feel like they have

participated in the process of creating a product by engaging in modifying digital product designs and 3D printing them. The secondary data are also limited with respect to assessing how likely consumers are to 3D print digital product designs and how satisfied they feel with the final printed product. By having participants engage in product design modification in the behavioral lab and the 3D printing process in the Maker Lab, it is possible to measure the users' sentiment of involvement in product creation. Further, it would be interesting to test how this sentiment of making a product increases individuals' satisfaction with the product creation process, as well as how this sentiment of making a product increases their satisfaction with and use of the final product.

Additionally, leveraging the capabilities of the Maker Lab enables the collection of data with respect to how engagement in the 3D printing process serves to increase the participants' feeling that they created a product, in comparison to only completing the product design process without actually printing an object. Having the participants engage in 3D printing helps us to understand consumers' likelihood of using 3D printed products and whether they are likely to engage in 3D printing again. Ultimately, this approach enables the assessment of whether participants indicate a preference to make their own products instead of buying a professionally manufactured product from a firm. The results of this study could have profound implications because they could foreshadow a much broader shift in the prevailing market exchange system that is currently dominated by manufacturers and retailers who control the flow of goods to consumers. These results would facilitate the development of new theoretical perspectives with respect to market exchange, and firms would be well-served to understand the impending changes to their current process of product development and delivery.

In addition to the completed studies that are described in chapter 4, a behavioral lab study (Study 4) is in progress that extends the existing research. For Study 4, a randomized manipulation is added near the beginning of the same experiment that was utilized in Study 2. In Study 4, this manipulation tells one group that the designer of the cell phone case is Apple, while the separate group is told that the designer is an anonymous individual, as in the scenario of Study 2. This approach will facilitate the testing of how the influence of the designer's reputation affects the participants' satisfaction with the product design creation process. The designer reputation effect can be isolated by testing the between group differences regarding degree of creation with the design, satisfaction with the design process, and the effect on the participants' perception of the professional brand.

An interesting future research possibility would be to design an experiment that drills deeper into how peer opinions about 3D printed objects affect individuals' sentiments of creation and satisfaction. In this scenario, a 3D printed product would be shown to each subject. There would be two groups of subjects in which the satisfaction of the quality of the final product would be randomly manipulated. The first group would be told that the 3D printed product is unique and highly innovative, and that they should want to show it off to their friends. The second group would be told that their friends will think that the product looks cheap, flimsy, and of low quality compared to products that are supplied by firms. Subsequently, the study would ask the questions about the degree of creation and satisfaction that are used in the behavioral lab studies that are described in chapter 4. It is conceivable that some individuals will be influenced more directly by their perceptions of how their 3D printed products are evaluated by their friends, and that the influence of opinions from the more anonymous nonmarket innovation community review process could play a relatively minor role. This approach will allow for the

further investigation of how 3D printing may diffuse into broader consumer segments than is currently realized.

Finally, it would be interesting to study how the expected use of a particular 3D printed product influences individuals' decision to engage in nonmarket innovation. The reasons why consumer-creators spend their time creating, sharing, and printing digital product designs are quite unclear at this time. Based upon the comments collected from subjects who participated in the existing studies in this dissertation, it seems that the intended use of the product may play a substantial role in the individuals' satisfaction with the actual product. To investigate this phenomenon, an experiment could be designed to include a manipulation in which the 3D printed product that is shown to the subjects could be either high in self-expression (hedonic) or high in utility (functional). The hedonic versus functional distinction is of interest to the academic marketing research community, and designing an experiment in this manner should provide an opportunity to make further theoretical contributions to our field.

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## **Appendix: Measurement Scales for Chapter 3**

### **Diverse External Stakeholder Involvement** (7-pt. scale, percentage of time anchors)

What percentage of time do your firm's employees interact with external stakeholders to disclose internally generated ideas to obtain feedback?

To what extent in the following innovation stages do external stakeholders contribute to your firm's innovation process?

- Idea generation
- Technological and market assessment
- Development
- Testing
- Commercialization

To what extent do the following external stakeholders contribute to your firm's innovation process?

- Suppliers
- Customers
- Competitors
- Other

### **External Knowledge Search** (7-pt. scale, percentage of time anchors)

What percentage of time does your firm search externally for innovative ideas outside your organization?

What percentage of time does your firm search externally for innovative ideas outside your industry?

### **External Knowledge Access** (7-pt. scale, "not at all" to "extensively" anchors)

In your firm's industry, to what extent can external knowledge be used for your firm's innovations:

- Available
- Accessible

## Appendix (cont.)

### Vigilant Market Learning

When utilizing externally generated ideas, how important is your firm's ability to evaluate those ideas in terms of the following: (7-pt. scale, "not at all important" to "very important" anchors)

Market potential  
Technical feasibility

How consistent is your firm's process for selecting externally generated ideas? (7-pt. scale, "inconsistent" to "very consistent" anchors)

How effective is your firm's ability to evaluate externally generated ideas? (7-pt. scale, "limited" to "high" anchors)

Evaluate market potential  
Evaluate technical feasibility  
Select best ideas

How efficiently does your firm evaluate externally generated ideas to reach the following decisions: (7-pt. scale, "very inefficient" to "very efficient" anchors)

Commercialize  
Patent  
Reject

### Adaptive Market Experimentation

How would you characterize your firm at the following innovation processes: (7-pt. scale, "ineffective" to "very effective" anchors)

Linking external ideas to internal innovation processes  
Generating deep insights from contact with external knowledge  
Preventing entry of unexpected competitive innovations

How effectively does your firm convert external ideas into innovations? (7-pt. scale, "limited" to "high" anchors)

What percentage of the time does your firm capture the value of innovations that are developed with external resources? (7-pt. scale, percentage of time anchors)

## Appendix (cont.)

### Open Marketing

How much does your firm protect against the risk of unprotected innovations being leaked to competitors? (7-pt. scale, “very little protection” to “very high protection” anchors)

How clear are your firm’s intellectual property policies to external stakeholders for licensing externally generated ideas? (7-pt. scale, “not clear at all” to “very clear” anchors)

To what extent do the external stakeholders in your organization’s innovation network share in the value created through your network’s innovation efforts? (7-pt. scale, “none” to “high” anchors)

### Dependent Variables

Compared to internally generated ideas, how quickly does your organization develop innovations from externally generated ideas?

Speed-to-market with external ideas (7-pt. scale, “much slower” to “much faster” anchors)

Compared to the degree of novelty (i.e. innovativeness) of your firm’s internal ideas, how novel are your firm’s innovations that come from external ideas?

Novelty of external ideas (7-pt. scale, “not at all novel” to “much more novel” anchors)

What percentage of the time does your firm capture ideas and technologies that are generated externally through licensing and patents? (7-pt. scale, percentage of time anchors)

Licensing  
Patents